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Annals of Surgery
June 1944

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EXPERIENCES WITH CHEST WOUNDS FROM THE
PACIFIC COMBAT AREA*

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WOUNDS OF THE CHEST, particularly in military quarters, provide unique and difficult problems for the medical personnel in transportation, treatment, and convalescence. The obvious vulnerability of the chest, the fatal potentialities of large sucking wounds, the quick fatality of injuries to the heart and large vessels, are all reflected in the high mortality from these causes on the battlefield, estimated to lie between 30 and 40 per cent.

Few reports are as yet available as to the incidence or severity of chest wounds in this war. Ferguson, *et al*¹ have reported their experiences in transferring patients from evacuation to base hospitals in the South Pacific area. Among 4,039 patients there were 75 cases of chest injuries. One died following a pulmonary embolism, two sucking wounds required operative closure, hemothorax was left severely alone, aspiration being performed only when respiratory embarrassment demanded it, or when the clinical picture suggested the possibility of infection. They stress the frequent development of temperature as high as 103°F in the presence of a sterile hemopneumothorax, persisting as long as two weeks. They were emphatic in their belief that the local use of the sulfonamides had made radical wound débridement unnecessary.

This conservatism in thoracic injuries among our naval surgeons finds confirmation in the experiences of British surgeons in desert warfare.² Among 2,500 battle casualties not a single operation was performed primarily to deal with a wound of the chest. The removal of foreign bodies was delayed until the patients reached a base hospital. Aspiration was employed only to relieve mediastinal shift or respiratory difficulty. Of 63 penetrating wounds of the chest only three developed empyema. Conservatism in front-line thoracic surgery was advocated.

In contrast to these experiences from the combat zone, Schrire,³ an

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The opinions contained herein are the private ones of the writer, and are not to be construed as official, or reflecting the views of the Navy Department or the Naval Service at large.

English surgeon, recently stated that unless the condition of the patient was so bad as to render any operative intervention an entirely hopeless procedure, every patient with a penetrating wound of the chest admitted under his care was subjected to an exploratory thoracotomy as an emergency measure if seen within 12 hours after the injury. Similar views have been expressed by both military and civilian surgeons.⁴

With these expressions of conservatism and radicalism before us, it may be instructive to survey the course of events in a group of patients from the Pacific Combat Area, and to glean from illustrative cases some of the lessons they so pointedly teach. Any criticism that may be presented is directed not to individuals, but to us as teachers who have failed in our teaching.

The immediate care of wounds of entrance and wounds of exit often determines the final outcome. Bullet wounds are frequently small, appear perfectly clean, heal like surgical incisions, and after a month's time defy detection. Given such sharply cut wounds, a simple dressing should suffice. At other times, bullets, shrapnel and mortar fragments produce ragged, dirty-looking wounds, with severely traumatized edges, capable of acting as an excellent culture medium for the growth of organisms. Such wounds, if seen within six to ten hours, should be excised under local anesthesia, the raw surfaces smeared with a sulfonamide mixture of sulfathiazole and sulfanilamide, equal parts, and the skin edges loosely approximated. Four grams of sulfathiazole or sulfadiazine are given by mouth immediately, followed by one gram every four hours over a period of three to five days. If seen later than ten hours after the injury, without obvious infection, a cleansing débridement is performed and if there is no sucking wound, the tissues are not sutured, the raw surface being treated with sulfonamides and with a dressing of vaselined gauze.

Contrasting results in the following two simple through-and-through wounds of the chest illustrate the imperative need of early excision of devitalized tissue particularly of the wound of entrance.

Case 1, age 25, was shot through the left lower chest on board a battleship at sea on June 23, 1942. A simple dressing was applied. He was admitted to Mare Island Naval Hospital 60 hours later. His temperature was 102° F, pulse 140, respirations 35, and blood pressure 92/64. A foul-smelling discharge was already escaping from the wound of entrance, preventing any adequate debridement or closure at this late stage. Roentgenograms (Fig 1a) revealed a left chest full of blood with displacement of the mediastinum to the right. 1400 cc of blood was aspirated from the chest which, on culture, proved to be sterile. By July 1, however, the infection of the superficial wound had penetrated the hemothorax, producing a pyopneumothorax, and a sucking wound of entrance. The patient died on July 10, with a massive empyema, a mediastinitis, and an infarction of the right lower lobe. The left lung was completely collapsed.

Case 2, age 59, was shot through the left lower chest on July 1. He was immediately admitted to Mare Island Naval Hospital, where a debridement of the wound of entrance with closure of the skin edges was done at once under local anesthesia. Although roentgenograms (Fig 2) showed a left chest full of fluid and a mediastinal shift to the right, there was little dyspnea, and so no aspiration was performed until August 20, over a month after the injury, when 1000 cc of reddish fluid was aspirated. On Sep-

WOUNDS OF THE CHEST

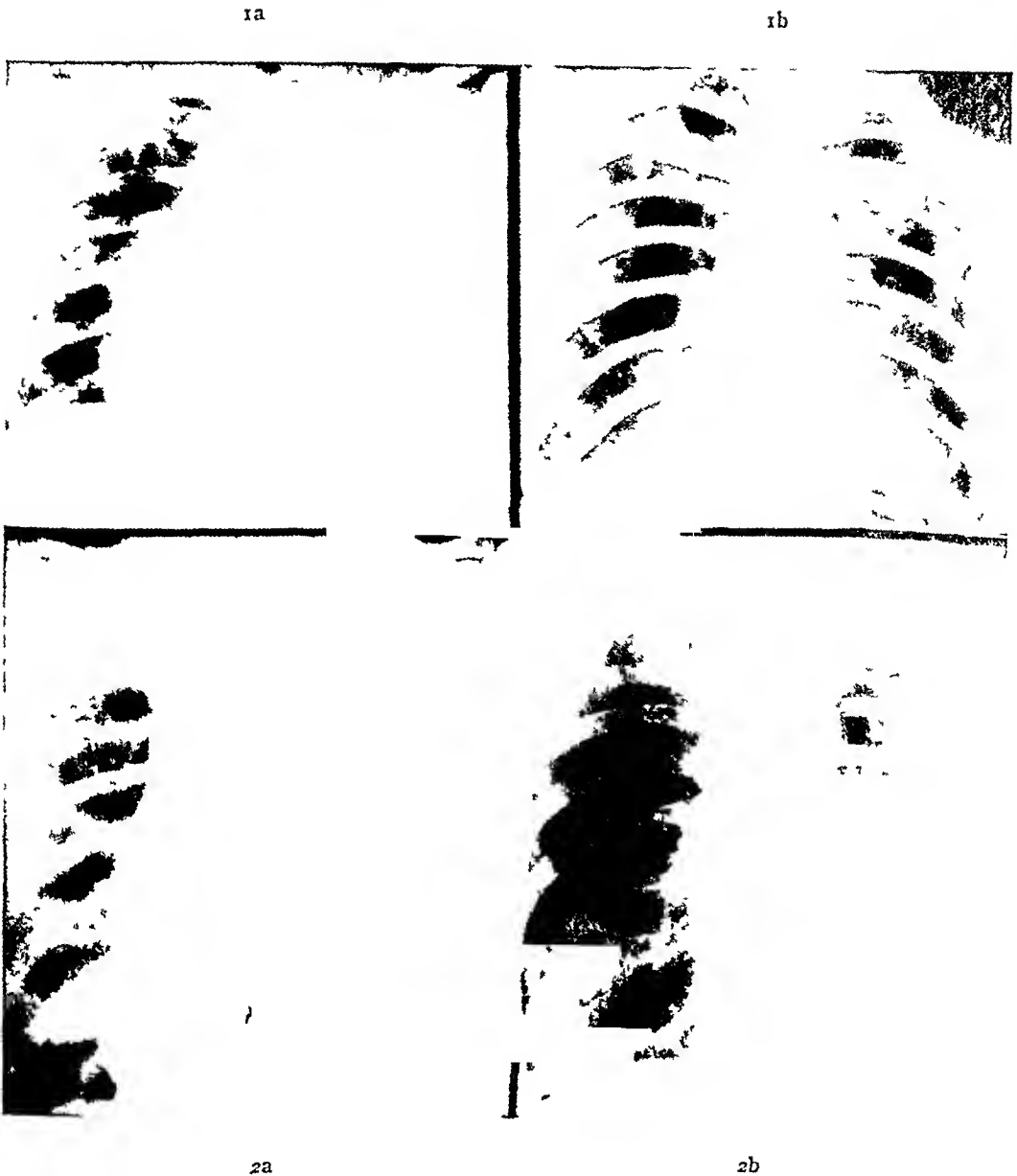


FIG 1—Case 1 (a) Roentgenograms of gunshot wound of left chest showing massive sterile hemothorax on admission June 25, 60 hours after injury (b) This was followed by a pneumopyothorax (July 1) and the death of the patient on July 10. Excision of wounds of entrance and exit had *not* been performed.

FIG 2—Case 2 Roentgenogram on July 1, 1942 following a through and through gunshot wound, with massive hemothorax and mediastinal displacement. Following immediate excision of wounds and three subsequent aspirations on August 20, September 9, and September 16, complete recovery occurred.

tember 9, 100 cc was aspirated and on September 16, 375 cc was obtained. He made an uneventful recovery and was discharged from the hospital on October 10.

Although these two injuries were almost identically located, and presented exactly similar immediate effects, the one in whom immediate excision and closure of the wound of entrance was performed recovered, while the other, in whom immediate excision was not performed, died of massive pleural empyema and mediastinitis, a direct extension from the superficial wound.

In the following case, failure to excise the traumatized tissue in the wound of entrance also led to a localized infection and subsequent extension of the infection to a hemothorax, resulting in a massive empyema. In this case, it seems probable that failure to perform a simple débridement at the time of

injury now makes a thoracoplasty necessary before complete healing can be expected

Case 3, age 21, was injured August 9, 1942, by a piece of shrapnel which entered the right chest (Fig 3), just below the clavicle, the fragment lodging posteriorly adjacent to the spine. There was an immediate paralysis of the right leg, which

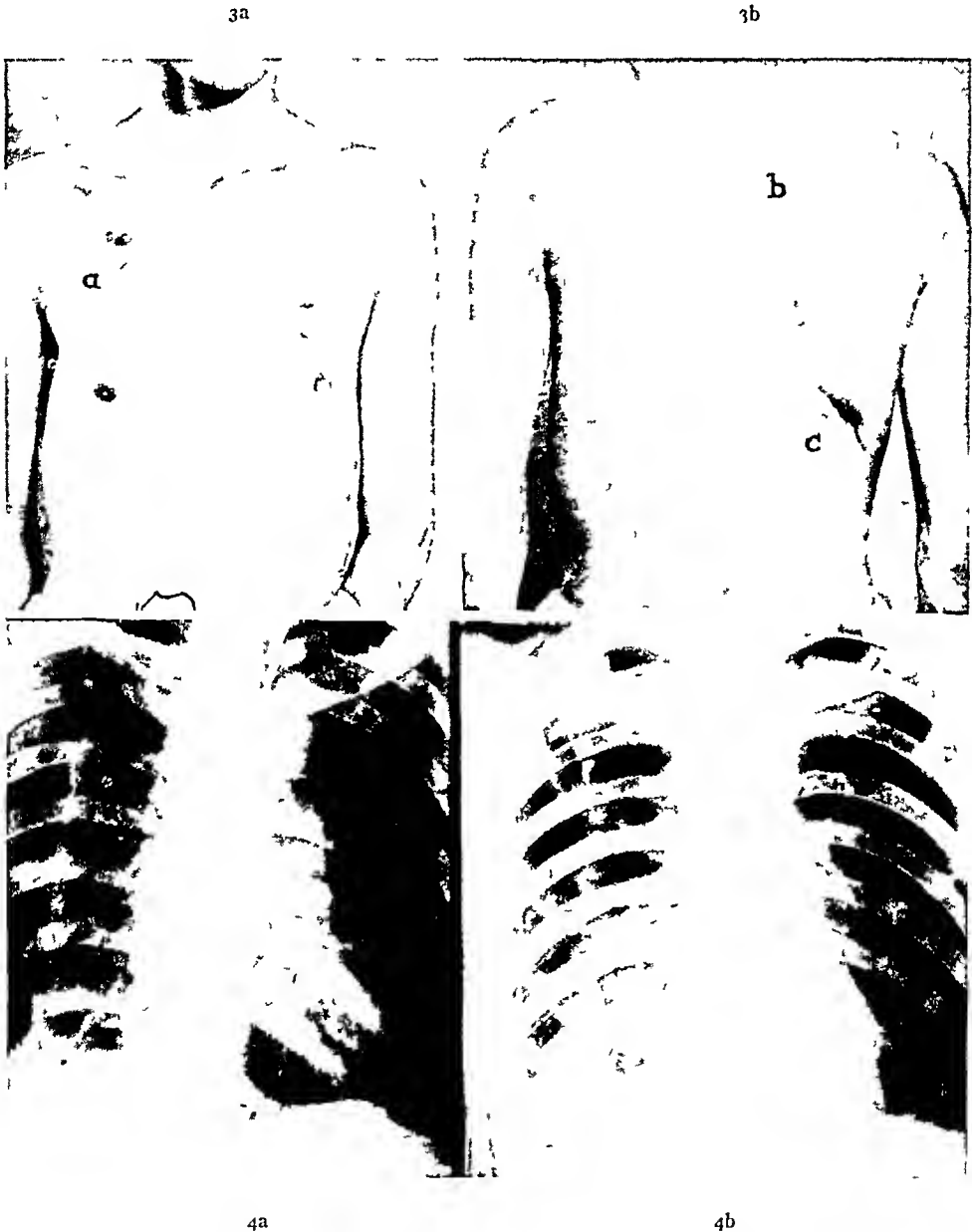


FIG 3—Case 3 Photograph on January 5, 1943, patient having sustained injury on August 9, 1942

(a) Wound of entrance, now well healed, was *not* excised at time of injury
 (b) Operative site of removal of foreign body on November 20, 1942. Healing *per primam*
 (c) Resection of rib for empyema on September 18. The long interval between injury and the development of the empyema, and the sterile foreign body, suggest that infection occurred by extension from wound of entrance, and might have been avoided by early excision and closure

FIG 4—Case 3 Roentgenogram on January 6, 1943, disclosing a large chronic empyema cavity which was still present on February 11 and also on June 6, 1943. Thoracoplasty will be necessary for elimination of this cavity

WOUNDS OF THE CHEST

slowly improved after the removal of the foreign body on November 20. The initial treatment of the wound consisted of a simple dressing, the administration of 0.5 cc of tetanus toxoid, and 120 grains of sulfathiazole in five days, obviously an inadequate amount. On August 14, 250 cc of serosanguineous fluid was aspirated from the right chest, and on August 18 an additional 250 cc of serosanguineous fluid was aspirated. On August 29, 20 days after the injury, a free flow of thin red-tinged pus from the wound was recorded, and on this date a rubber tube drain was introduced into the anterior wound.

On September 18, six weeks after injury, a resection of the tenth rib was performed for a putrid empyema and the rubber tube drain then inserted was still in place on admission to Mare Island Naval Hospital on January 1, 1943. A roentgenogram on January 6 (Fig 4) revealed a large chronic empyema cavity which improved slightly on constant drainage and forced expiratory exercises, but on June 6 the cavity was still as large as on February 11, 1943 (Fig 4). A thoracoplasty will be necessary before healing can be expected. It seems highly probable from the sequence of events, that the empyema might not have developed if the original wound of entrance had been excised.

Wounds producing compound fractures of the underlying rib require a cleansing débridement, with removal of loose bone fragments. If a direct communication with the pleural cavity is created thereby, the wound should be closed—after sulfonization—preferably by overlapping of available chest wall muscles without tension. Large sucking wounds require an immediate débridement and closure of the opening, if possible. When first seen on the battlefield such a wound (after sulfonization) may be closed with massive dressings, or with a sterile glove over the opening, and with a tight adhesive bandage encircling the chest. At the first opportunity such wounds must undergo a cleansing débridement, with removal of fragmented ribs, foreign bodies, and blood clots within the chest cavity. Sulfonamides are applied to all exposed pleural surfaces, and the defect in the thoracic wall loosely closed. In the event of obvious gross contamination of the pleural cavity with clothing or actual dirt, a mushroom catheter should be placed in the first intact intercostal space below the wound, the catheter being closed with a clamp until underwater drainage is established at the patient's bedside.

Considerable ingenuity may be necessary to close the defects in the thoracic wall depending upon their location and size. Defects in the lower chest, as for example, below the level of the dome of the diaphragm, may be closed by stitching the diaphragm to the parietal pleura at the upper border of the defect, the diaphragm having been previously paralyzed by transpleural crushing of the phrenic nerve as it courses over the pericardium.

The muscles of the thoracic wall such as the pectoral, latissimus dorsi, and trapezius, should, when possible, be approximated by overlapping, thus providing two lines of suture. Relaxing semilunar incisions in the muscle well away from the defect may be made, on one or both sides, depending upon the ease with which the muscles are approximated. There should be sufficient relaxation of the muscle to permit some overlapping and approximation without tension. If no muscle is available, subcutaneous fat and fibrous tissue may serve as one layer and skin as the second. When skin alone is

available, semilunar relaxing incisions may be necessary, on one or both sides, to effect closure without tension. The raw surfaces thus produced may be skin grafted immediately or be covered by vaselined gauze or sterile cellophane. A firm, voluminous dressing well strapped in place by adhesive plaster encircling the chest should be applied and not changed for seven to ten days in the absence of indications to the contrary. The sutures approximating contaminated muscle and subcutaneous tissues must be most gently applied and loosely tied to avoid excessive strangulation and pressure necrosis of included tissues. Such necrotic tissue serves as an admirable culture medium for the growth of bacteria, and all too frequently is responsible for the breaking down of sutured wounds.

When muscles are absent at the site of the defect in the thoracic wall, the resection of one or two ribs, on one or both sides of the defect, will permit closure of the now more mobile soft parts.



FIG 5—Case 4. Photograph of chest injury closed by suture to control sucking wound. Complete healing followed a late sequestrectomy of rib. Despite a massive hemothorax (Fig 6) no pleural infection occurred.

Case 4, age 20, on September 25, 1942, sustained a severe wound of the right lower chest from a machine gun bullet which tore out a part of the thoracic wall producing a sucking wound. The wound was temporarily closed by heavy dressings and he was given 1000 cc of plasma, having lost a great deal of blood both to the outside and into the chest. He was flown by plane to an advanced base where a cleansing debridement and closure of the wound were performed on about the fourth day (Fig 5).

A roentgenogram (Fig 6a) on the day following the injury showed a large hemothorax and fractures of the 8th, 9th, and 10th ribs.

Closure of the wound was followed by a late osteomyelitis of the rib, which necessitated a sequestrectomy on December 5, 1942, after his arrival in the U S A. Complete healing of the wound followed, but complete comfort was not attained

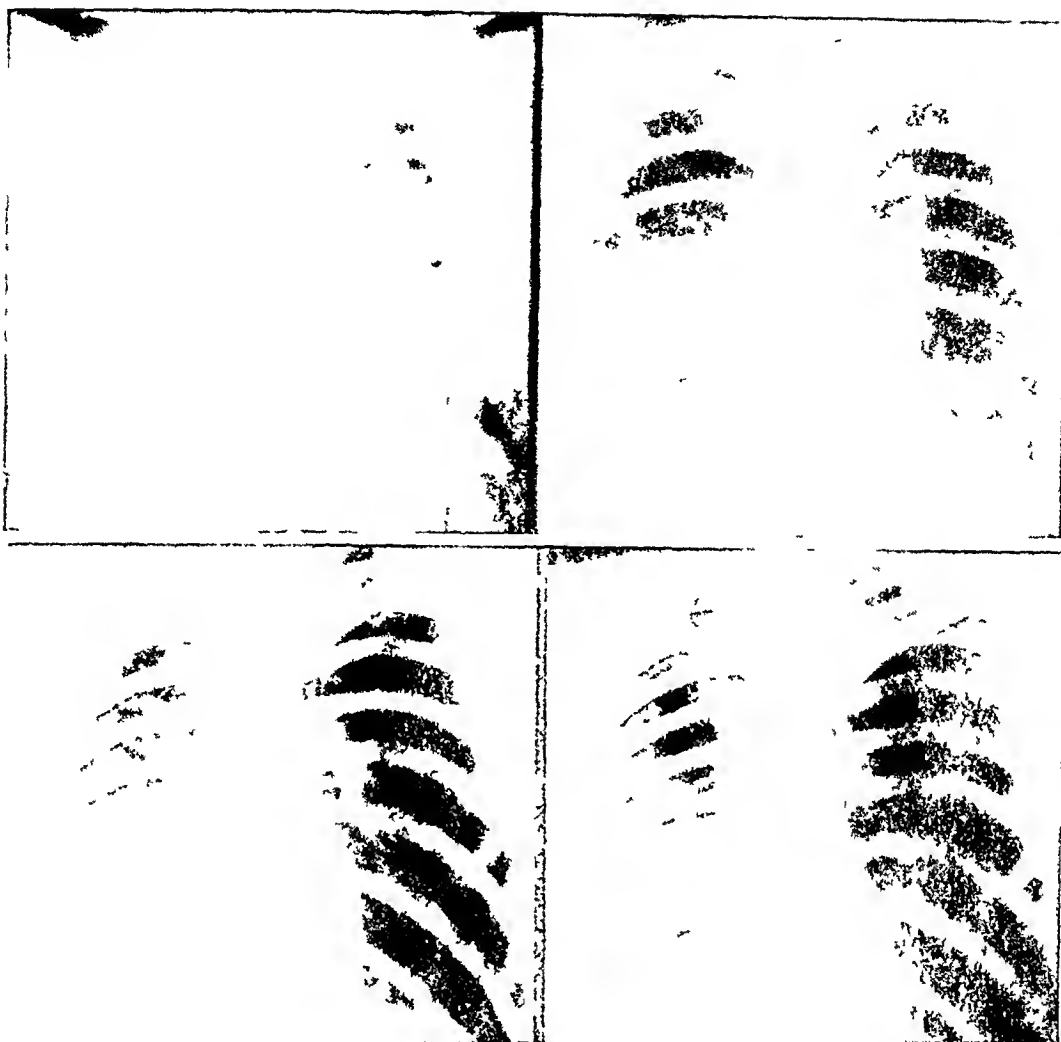
until several focal spots of pain in the scar were injected on two occasions with 50 cc of 1% novocain.

HEMOTHORAX

Of 36 cases of thoracic injury admitted to Mare Island Naval Hospital, 19 had been complicated by a massive hemothorax. In some cases multiple aspirations had been found necessary, a total of 27 aspirations having been performed in 12 cases. In seven instances complete recovery occurred without aspiration. Four of the 12 cases aspirated were complicated by empyema.

6a

6b



7a

7b

FIG 6—Case 4 Roentgenograms of chest (a) In the presence of a hemothorax following a sucking wound controlled first by large firm dressing and then by operative closure of the wall

(b) Two months later showing almost complete clearing of chest without intervening aspiration

FIG 7—Case 5 (a) Roentgenogram on January 28 showing a large pyopneumothorax following aspiration of blood and air replacement 16 days after injury, which occurred on October 24, 1942 Air replacement unnecessary at this late date

(b) Drainage and forced expiratory exercises were followed by expansion of lung and obliteration of empyema cavity

(Cases 1, 3, 5 and 6), two of these aspirations having been supplemented by air replacement

Case 5, age 20, was wounded by a machine gun bullet on October 24, 1942, producing fractures of the right 6th, 7th, and 8th ribs and of the body and neck of the right scapula. He immediately found breathing difficult and coughed up bright red blood. A roentgenogram on October 29, five days after injury, revealed a "right hemothorax with marked compression of the lung, and shift of the mediastinum to the left." However, there was no marked difficulty in breathing, and not until November 9, 16 days after the injury, was aspiration considered necessary. At this time his temperature was 103° F, pulse 120, and respirations 40. 720 cc of old blood was aspirated from the right chest on November 9, and an equal volume of air reinjected, for what purpose the record does not state. On the following day he was greatly improved but on November 17 his temperature again rose to 104° F, and on this

date 500 cc of bloody pus was removed by aspiration. Two days later drainage was established by resection of the 8th rib. He was admitted to Mare Island Naval Hospital on January 25, 1943, with the drainage tube still in place. Roentgenograms revealed a pyopneumothorax of considerable extent (Fig 7). Forced expiratory exercises with the tube in place were continued hourly each day until February 9, when the tube was permanently removed. A roentgenogram on March 15 showed good expansion of the lung and obliteration of the empyema cavity. Except for a mild osteomyelitis of the scapula with discharge of several sequestra he has made a complete recovery (Fig 8).

Case 6, age 24, was wounded by machine gun fire on January 19, 1943 resulting in a small wound of entrance at the medial end of the left clavicle, and a large, jagged, sucking wound of exit in the left axilla. Marked dyspnea and hemoptysis occurred immediately. Under local anesthesia a cleansing debridement of the axillary wound was undertaken at once, and the opening closed with muscle and fascial sutures. When

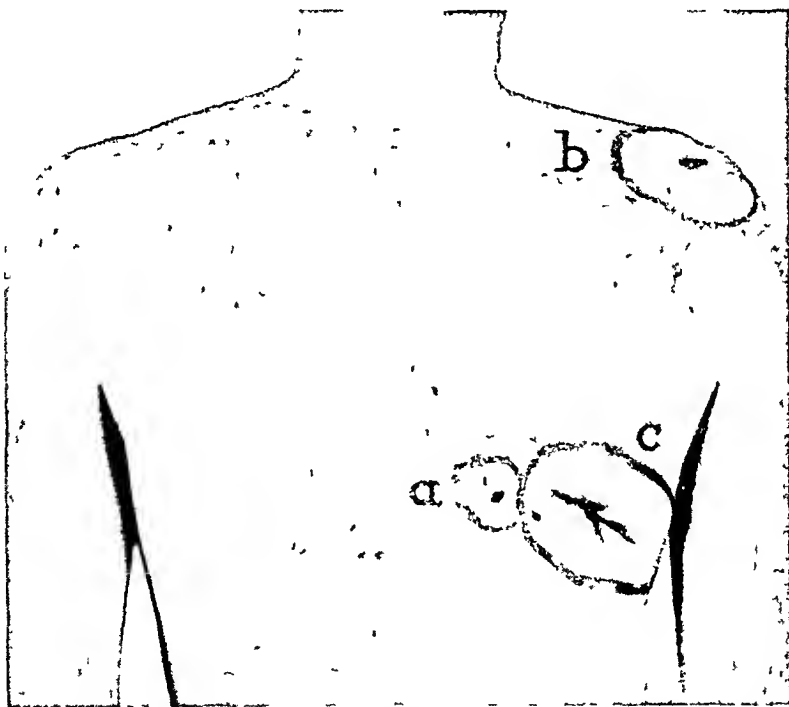


FIG 8—Case 5. Photograph February 16, 1943. Gunshot wound of chest, October 24, 1942, producing fractures of 6th, 7th and 8th ribs and a hemothorax. (a) Wound of entrance, (b) wound of exit, (c) healed operative wound for drainage of empyema.

this wound was closed the wound of entrance became a sucking wound, necessitating its closure by debridement and muscle sutures. Three transfusions were given in the next three days.

On January 24, *five days after injury*, 820 cc of bloody, thin fluid was aspirated from the left chest with replacement by an equal volume of air. The reason for such replacement was not stated in the record. On January 31, 150 cc of serous fluid was aspirated, and between this date and February 17 (Fig 9a), three further aspirations were found necessary. On February 19, a portion of the 3d rib was removed anteriorly, and "the skin was sutured to the pleura to keep the wound open" (Note in the Health Record).

On admission to Mare Island Naval Hospital on April 5, the roentgenogram revealed a complete collapse of the left lung very much as shown in the roentgenogram of March 1, 1943, (Fig 9b). Following forced expiratory exercises definite but

WOUNDS OF THE CHEST

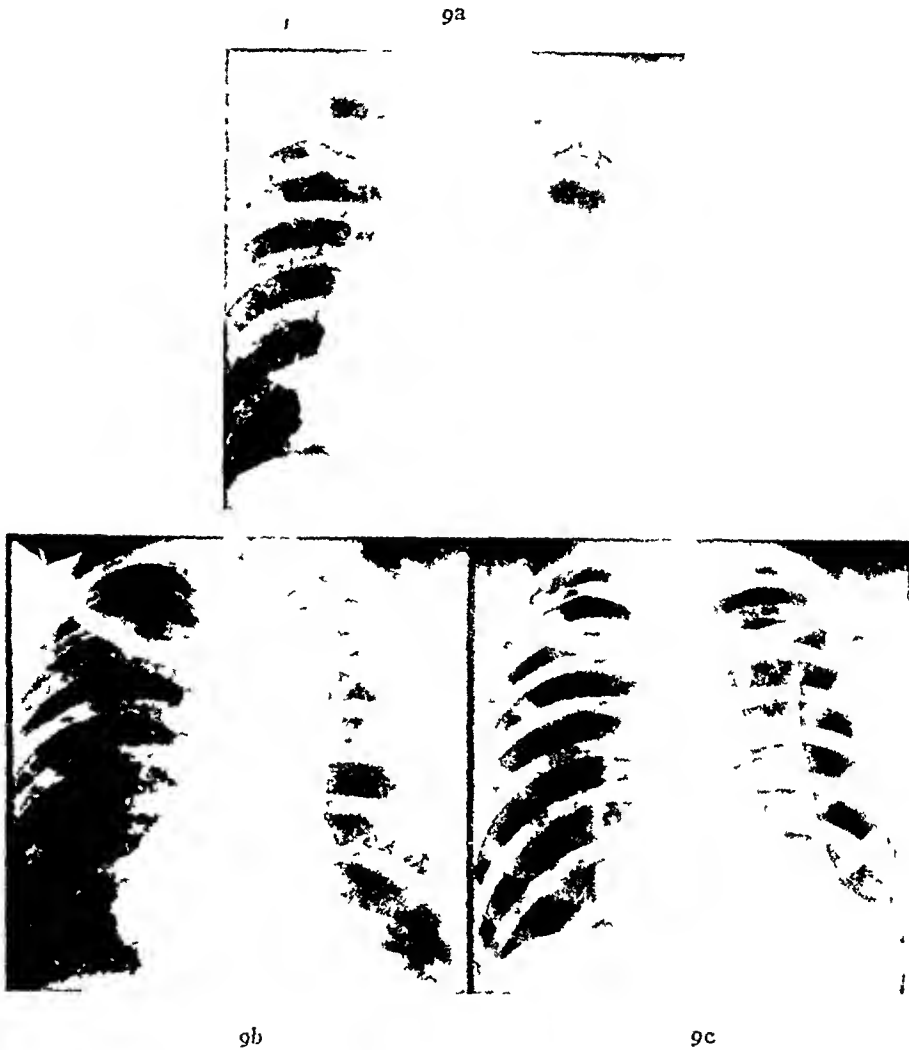


FIG 9—Case 6 Roentgenograms (a) February 17, 1943, one month after gunshot wound and following five aspirations, the first aspiration being accompanied by replacement with 820 cc of air. Massive pyopneumothorax still present for which rib resection was performed on February 19.

(b) Left lung completely collapsed, March 1, 1943.

(c) May 1, lung has only partially expanded, and a thoracoplasty will be necessary before complete healing can be expected, as improvement is now stationary.

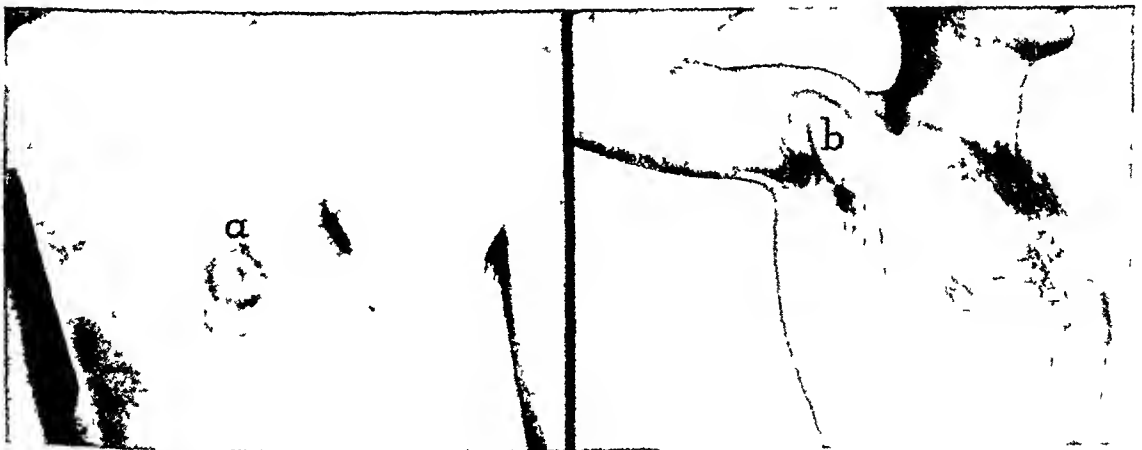
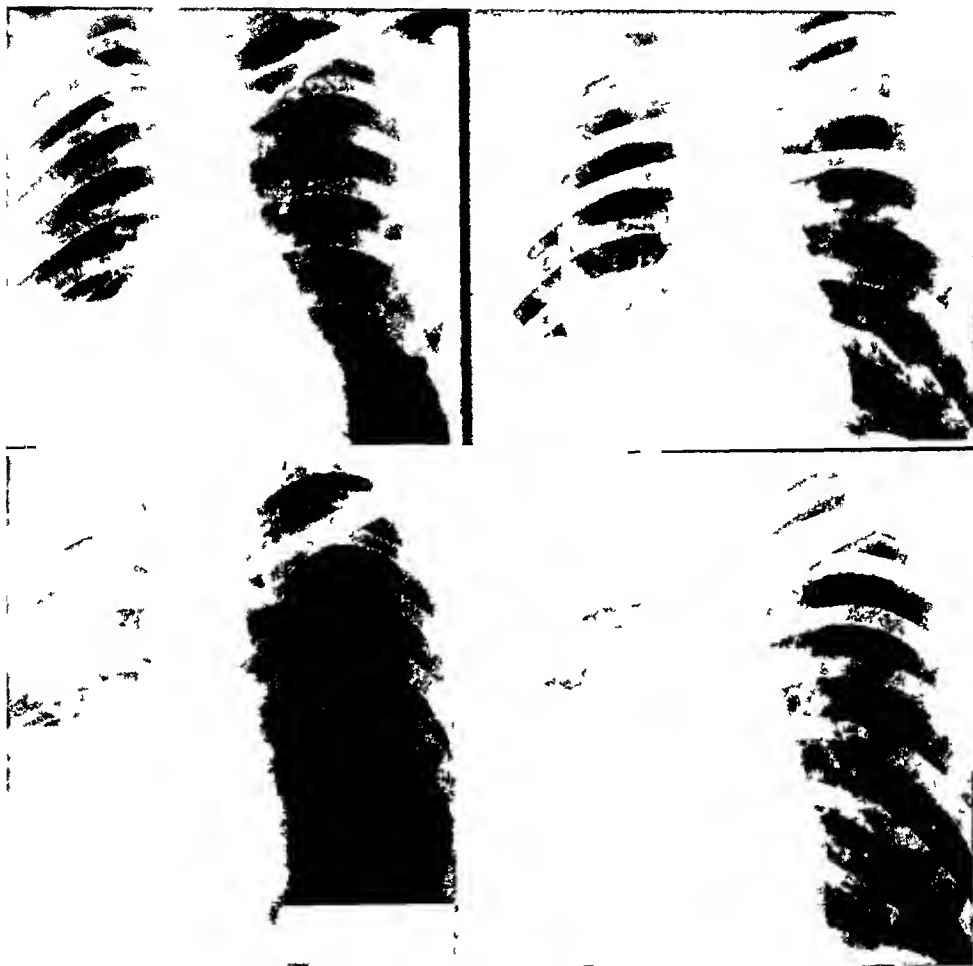


FIG 10—Case 7 Rifle bullet wound producing massive pneumothorax (a) Wound of entrance, and (b) wound of exit.

11a

11b



11c

11d

FIG 11—Case 7. Series of roentgenograms illustrating sequence of events following aspiration of sterile fluid and replacement with air on November 19, the original injury having occurred on October 7, 1942. Replacement with air was unnecessary and should not have been undertaken.

- (a) Hemothorax three days after injury showing displacement of heart to left
- (b) Following aspiration of 1200 cc of serosanguineous fluid and replacement with 1200 cc air. Marked collapse of lung by pneumothorax
- (c) Three weeks later, showing marked pleural fibrosis
- (d) Another three weeks have passed with additional fibrosis and beginning shift of heart to right, pulled over by contraction of fibrous tissue

incomplete expansion of the collapsed lung has occurred with diminution in the size of the empyema cavity (Fig 9c). However, a thoracoplasty will undoubtedly be necessary before complete healing is effected, as improvement now seems stationary.

Case 7, age 30, was wounded on October 7, 1942, by a rifle bullet which entered the chest in back, to the right of the 6th dorsal spine and emerged in the right axilla (Fig 10). Dyspnea, cough, and hemoptysis, and loss of motion in the fingers of the right hand were immediate symptoms, all of which gradually improved, although convalescence was complicated by causalgic pains in the domain of the median nerve. He was admitted to Mare Island Naval Hospital on November 13, about five weeks after the injury, with the original wounds almost healed, but with fluid in the right chest and a high temperature. On November 19, 1200 cc of serosanguineous fluid was removed from the chest, and replaced by an equal volume of air. This replacement with air was unnecessary, and no explanation justifying it could be furnished by the

medical officer responsible except that he had read it was desirable. A culture of this fluid was found to be sterile. On November 24, 500 cc of fluid and some air were aspirated. On November 27, blood smears were found positive for malaria, and the fever was attributed to it. On December 9, 160 cc of fluid and considerable air were aspirated from the chest. Gradual improvement accompanied atabrine therapy for malaria, and by February 16, he was completely recovered.

Although replacement with air served no useful purpose whatsoever in this instance, it provided in a series of roentgenograms (Figs 11 and 12) an instructive story of remarkable intrapleural fibrosis that followed an effusion and its aspiration. The subsequent contraction of this pleural fibrosis resulted not only in a reexpansion of collapsed lung, but it was sufficiently effective to cause a shift of the mediastinum and heart to the affected side. Definite evidence is provided in these roentgenograms that the obliteration of any empyema cavity is probably effected not only through active reexpansion of the lung by air, but also through fibrous contraction at the junction of the parietal and visceral pleurae, resulting in a gradual but steady pulling out of the lung.



FIG 12—Case 7. Additional roentgenograms demonstrating gradual obliteration of previous pneumothorax by reexpansion of lung, but also by shift of mediastinum. By February 16, through contraction of pleural fibrous tissue, heart has assumed a midposition in the chest.

In five additional cases of hemothorax, aspirations were performed, removing as much as 1800 cc of blood in one case, and 1100 cc in another (Case 11), *without replacement with air*. Complete recovery without complication occurred in all cases.

Case 8, age 21, was struck by a machine gun bullet on December 7, 1941, the bullet entering the right chest anteriorly and emerging posteriorly directly opposite the wound of entrance (Fig 13). He immediately became dyspneic, and complained of pain in his chest. Two days later he coughed up a small amount of dark red blood-tinged fluid. Gradual improvement occurred until December 23, when he complained of night sweats and headache, and he was found to have a fever. A roentgenogram on December 26 disclosed a right chest full of fluid (Fig 14a). On January 2, 1942, 1200 cc of bloody, thin fluid was aspirated, a culture of which was sterile. On January 7, 650 cc of serosanguineous fluid was removed, and on January 14 only 100 cc of fluid

could be obtained. Roentgenograms about five weeks later (Fig 14b) showed practically complete clearing of the right chest, and he was discharged to full duty on March 10.

In seven cases of massive hemothorax without symptoms, complete recovery occurred without aspiration. The problem of aspiration of fluid from the chest has been subjected to much controversy, and unanimity of opinion and uniformity of procedure have not yet been achieved. As previously stated, American and British surgeons of this war have reserved aspiration for cases showing respiratory embarrassment, or for diagnostic purposes when empyema was suspected.

In the Military Surgical Manual⁵ prepared by the National Research Council, the statement is made that "effusions extending above the sixth rib posteriorly are treated by aspiration and simultaneous replacement with air." Such a statement, however, requires many qualifications. A too literal acceptance of it will undoubtedly lead to much unnecessary aspiration, and the invariable replacement with air will certainly cause much retardation in



FIG 13—Case 8. Machine gun bullet passed directly through chest producing a massive hemothorax (Fig 14). Bullet entered anteriorly at "o" and escaped posteriorly.

ultimate recovery. In many instances, effusions of this degree have given minimal symptoms, and have been completely reabsorbed. Moreover, the pressure of such an effusion is frequently a most effective preventive of further bleeding, and may be life-saving in the first 48 to 72 hours after the injury.

Should aspiration for dyspnea and respiratory embarrassment become necessary in these first few posttraumatic days, it would be advisable to limit aspiration to such an amount, probably 500 to 1000 cc, as would partially relieve the dyspnea. Studies of the aspirated fluid should be made to determine the hemoglobin content, the red cell concentration, and its sterility by culture. Should aspiration again become necessary because of dyspnea, or because of failure of absorption of remaining fluid, or because of its increase, or because of recurrence or increase in fever, the repetition of these studies of the aspirated fluid will reveal whether bleeding is continuing, as shown by a high hemoglobin and red cell concentration,

whether by dilution with fluid a clear effusion is developing, or whether by a great increase in leukocytes an empyema is present. If it is apparent that bleeding is continuing, another attempt at partial aspiration—this time accompanied by partial replacement with air—may be made before resorting to thoracotomy for control of the bleeding. If thoracotomy for bleeding becomes necessary, massive transfusions must be immediately available. An increasing clear effusion is best treated by repeated aspirations *without* air replacement.

An empyema developing at this early date is best treated by the introduction of a catheter in an intercostal space through a large trocar and cannula, the catheter being connected with a piece of rubber tubing long enough to establish an underwater seal beside the bed. At this early state a pneumothorax, such as would be produced by rib resection or intercostal incision, should be carefully avoided.

14a

14b

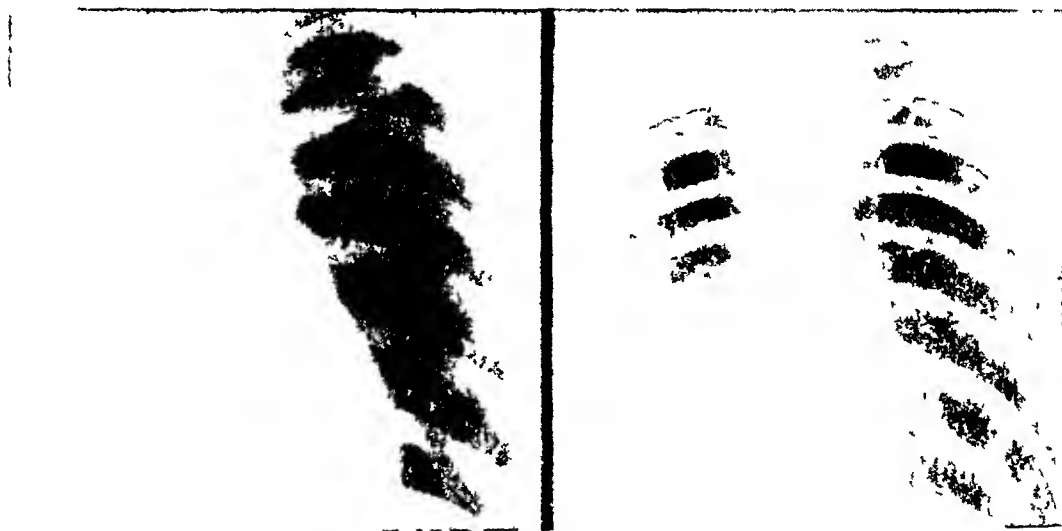


FIG 14—Case 8 (a) Roentgenogram showing right chest filled with fluid following through and through bullet wound on December 7. (b) Following three aspirations *without* replacement with air, chest became clear and patient was well.

The unnecessary replacement of aspirated blood or fluid with air may result in serious complications. The purpose usually advanced for such air replacement is that it maintains the collapse of the injured lung, and, therefore, the collapse of injured vessels likely to continue bleeding. But the pressure of a hemothorax should be as effective as a pneumothorax in the control of bleeding. Hemorrhage that cannot be so controlled will probably not be controlled by air replacement, although such an attempt at aspiration and replacement with air may be justified if aspiration alone has failed to control the dyspnea and bleeding. The danger of continued hemorrhage is ordinarily present only during the first 48 to 72 hours after the injury. After that time, thrombosis and fibrin deposits in the injured lung prevent further bleeding and make air replacement for the control of hemorrhage unnecessary. To replace with air the bloody fluid obtained by aspiration on

the *16th day* after injury as in Case 5, or even on the *fifth day* as in Case 6, is quite unnecessary from the point of view of continued bleeding. In both instances, a massive empyema developed. I do not suggest that replacement with air caused an empyema that would not otherwise have developed, but to say that aspiration and replacement with air prevent infection is not borne out by the facts. Moreover, it must be strongly emphasized that the cure of an empyema may be immeasurably complicated if the lung is already collapsed by a pneumothorax as the empyema develops. Air which replaces fluid tends to accumulate at the top of the pleural space, whereas fluid accumulates at the base. Therefore, infection of the pleural space in the presence of a pneumothorax may result in the fixation of the upper lobe in the collapsed state by inflammatory fibrosis of the visceral and mediastinal pleurae. This greatly complicates the subsequent elimination of the empyema cavity through inability of the lung to expand. In fact, in Case 6 the introduction of air greatly complicated subsequent recovery in that a massive empyema developed in the presence of a collapsed lung. If air replacement had not been instituted, the upper lung would in all probability have re-expanded, the upper visceral and parietal pleurae would have become adherent, the fluid remaining after aspiration would have tended to accumulate at the base, and the subsequent infection would have been limited to the lower thorax. Instead, a total empyema developed with complete collapse of the lung (Fig 9), and a thoracoplasty is now necessary to eliminate the empyema cavity.

A most important consideration as to whether air shall replace aspirated fluid is the character of the fluid obtained. If a thin, bloody or serosanguineous fluid is obtained, bleeding has already ceased, and replacement with air will serve no useful purpose. It may be considered axiomatic that when thin, bloody fluid is obtained, as in Cases 6, 7 and 8, the aspiration of fluid need not—and should not—be accompanied by replacement with air.

A hemothorax without symptoms that is not aspirated is usually reabsorbed, occasionally in a surprisingly short time (Case 9).

Case 9, age 19, was shot, on October 5, 1942, by a rifle bullet which passed through the left chest. There was marked dyspnea but no hemoptysis. He was given three transfusions within the first week. A roentgenogram on October 26 showed a massive hemothorax extending above the 6th rib posteriorly (Fig 15). On November 17, three weeks later, the blood had practically all disappeared, and the chest was clear. After a month's leave at home he was discharged to full duty on January 20, 1943.

Should a hemothorax without symptoms show no sign of diminution or reabsorption, an aspiration is in order at the end of the second or third week, to be repeated once or twice at short intervals until no further fluid is obtainable (Case 8). Replacement with air at this late date is unnecessary and should not be undertaken.

An occasional rare case may show massive clotting of blood which cannot be removed except by thoracotomy, which however must be justified by positive symptoms. On occasion, the removal of only a small amount of blood

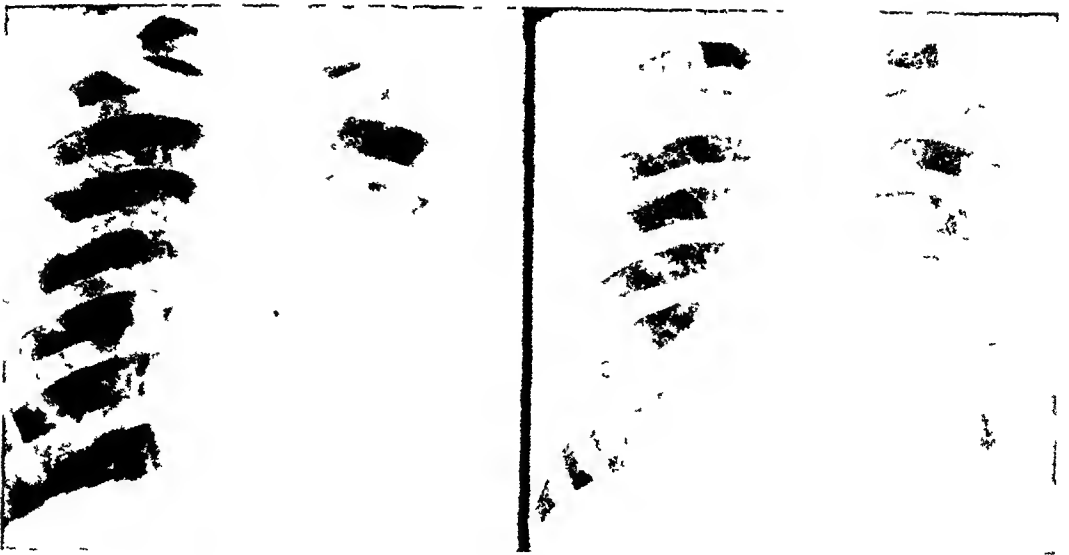


Fig. 15—Case 9. Roentgenogram on October 26 shows a massive hemothorax following bullet wound on October 5. Roentgenogram on November 17 shows the lung and pleura without need of aspiration.

or fluid by aspiration may suffice to alter pressure relationships in the pleural space sufficiently to initiate absorption of the remaining fluid.

FOREIGN BODIES

The removal of foreign bodies may in most instances be deferred until the patient reaches a hospital in the continental United States, and their removal then depends largely upon their size, and upon whether the symptoms complained of may be attributed to their presence. Some surgeons consider missiles over one centimeter in size to be potential sources of later trouble and advise their removal. Such removal should be undertaken when ideal conditions prevail, when positive pressure or intratracheal anesthesia is available, and when accurate localization by fluoroscopy is possible. All foreign bodies in the chest should be examined under the fluoroscope by the surgeon himself, their exact location determined by the parallax method, and the two planes of location designated on the chest wall. In the absence of a Berman foreign body locator, this localization must be most accurately determined. Fluoroscopy, with a portable machine, may also be necessary to



Fig. 16—Case 10. Large fragment of shrapnel entered chest anterior to shoulder, traversed the lung and was removed through a posterior incision. Injury occurred on December 7, 1941, and fragment was removed on January 16, 1942.

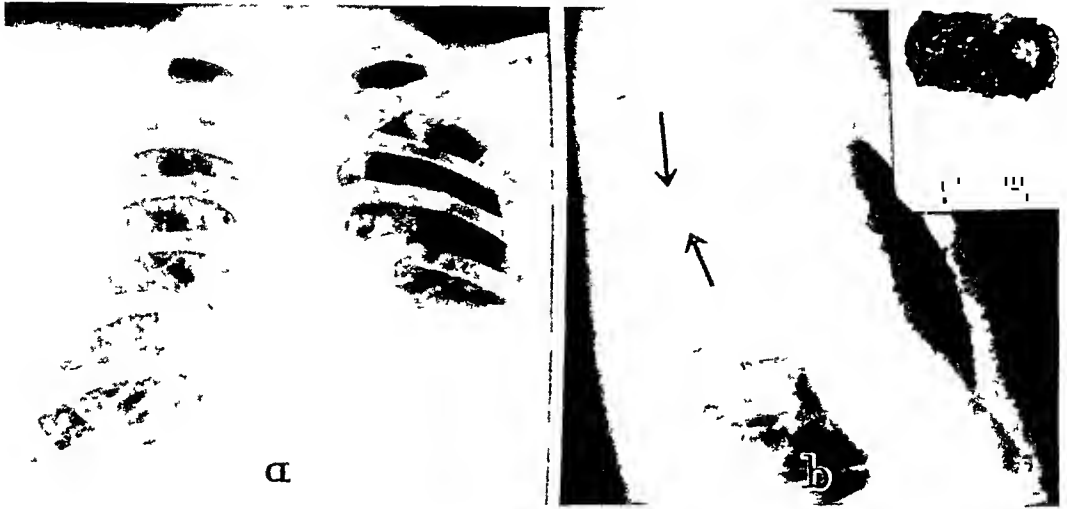


FIG 17—Case 10. Roentgenograms showing site of foreign body imbedded in lung. Insert shows fragment of shrapnel removed.

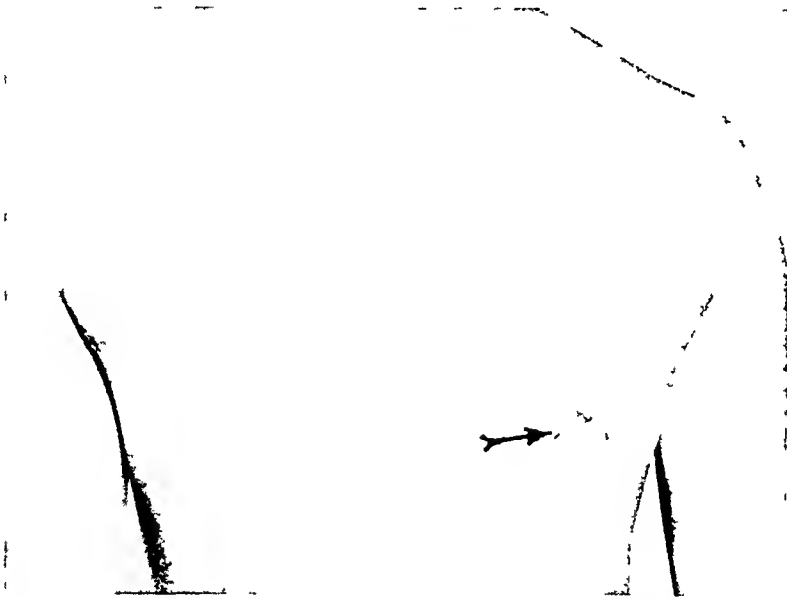


FIG 18—Case 11. The scar on right lower chest indicates site of wound of entrance on September 27, 1942, by a mortar fragment which traversed the lung and lodged in the middle lobe just posterior to 4th rib anteriorly. Late excision of the wound was performed on October 8.

find the foreign body at the operating table, after the lung has been exposed. Without these precautions, a surgeon may be extremely embarrassed by his unexpected failure to find the foreign body.

Case 10, age 23, was struck, on December 7, 1941, anterior to the left shoulder (Fig 16) by a piece of shrapnel which lodged posteriorly near the spine opposite the sixth rib (Fig 17). There followed an immediate paralysis of the left arm, marked dyspnea, pain in the chest and hemoptysis on several occasions. On December 16, a roentgenogram (Fig 17a) showed fluid in the left chest to the level of the 7th rib posteriorly, but by January 13 (Fig 17b), the blood had all been reabsorbed. The patient complained repeatedly of pain in the chest on deep breathing and on exertion. Accordingly, on January 16, portions of the 5th and 6th ribs were removed close to

WOUNDS OF THE CHEST

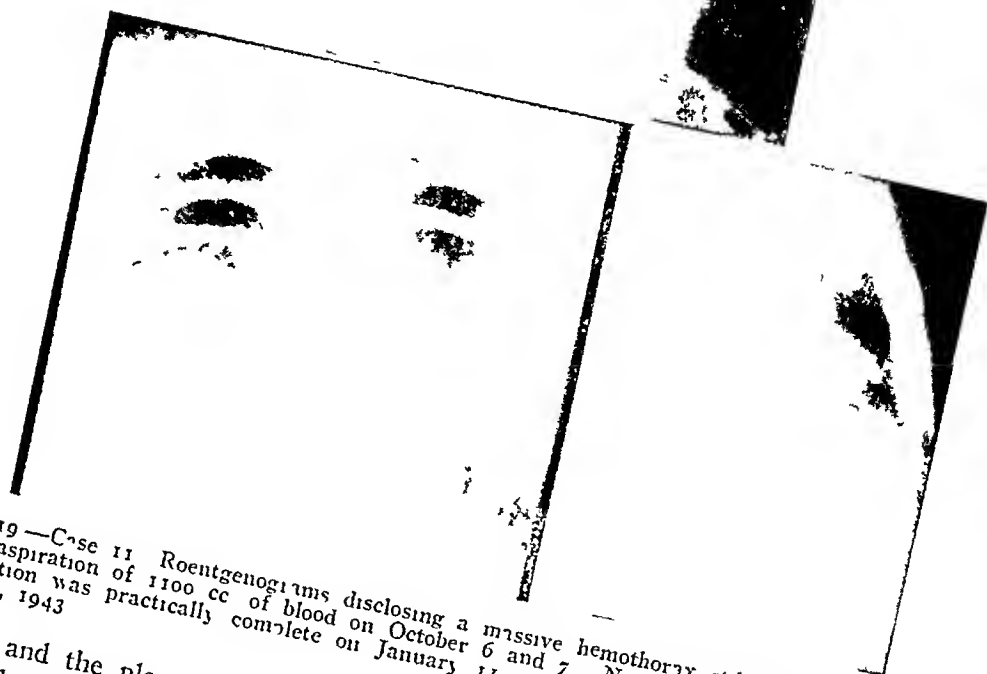


Fig 19—Case 11. Roentgenograms disclosing a massive hemothorax still present on October 26, following aspiration of 1100 cc of blood on October 6 and 7. No more aspirations were performed, but absorption was practically complete on January 11, 1943. The shrapnel fragment was removed on May 10, 1943.

the spine, and the pleura was incised producing a partial collapse of the lung. The foreign body could not be felt nor seen, although there was an area of firm infiltrated lung about 10 cm in diameter. Under fluoroscopy, the foreign body was more accurately located and the lung incised. A large jagged piece of shrapnel, 4 x 25 x 0.5 cm was withdrawn from a fibrous-lined cavity. The cavity was curetted for other foreign material and the surfaces smeared with sulfathiazole and sulfanilamide, equal parts. The chest wound was closed without drainage. He was discharged to full duty on April 5, 1942.

Case 11, age 23, on September 27, 1942, was struck by a mortar fragment which entered the right chest in the back (Fig 18) and lodged anteriorly in the middle lobe just posterior to the fourth rib. There was immediate hemoptysis, extreme dyspnea for three to four hours, and a soreness in the chest, accompanied by a subcutaneous emphysema. On October 6, 600 cc of blood was aspirated without air replacement, and on the following day 500 cc was aspirated, also without air replacement. On October 8, the wound in the chest wall was excised and resutured, followed by primary healing. A transfusion was given at this time. On October 26, a roentgenogram still showed a massive hemothorax obscuring most of the right lung field (Fig 19) but no further aspirations were performed. A roentgenogram on January 11, 1943, disclosed a thickened pleura at the right lower base and the foreign body in the anterior chest. Because of the absence of symptoms, the patient was returned to full duty on January 13, 1943.

On April 25, the patient reentered Mare Island Naval Hospital complaining of pain in the anterior right chest, particularly after exercise and after long hours of duty. Accordingly, on May 10, the chest was opened through the fourth interspace anteriorly, the ribs being separated without division. There was no fluid, but a number of adhesions between parietal and visceral pleurae were disclosed laterally and anteriorly. Every care was taken *not* to separate these adhesions in order to avoid collapse of the lung. The foreign body could be felt in the substance of the middle lobe, surrounded by fibrotic lung. Two traction sutures were applied, the lung incised between them, the foreign body extracted from about 0.5 cm below the surface, the cavity curetted for other foreign material, its walls smeared with the sulfonamides, and the incision in the lung closed by tying the traction sutures. The lung was inflated, and the incision in the lung tested for the escape of air by dropping water on the line of closure. No air escaped.

The chest wall was closed in the following manner. Two pericostal sutures of doubled No. 2 chromic catgut applied around the 4th and 5th ribs brought the two ribs closer together, but did not make them contiguous, since they had not been divided, and anteriorly they are normally widely separated.

The superior edge of the divided pectoral fibers was sutured to the inferior edge of the divided intercostal musculature with interrupted sutures of medium silk. The inferior edge of the divided pectoral muscle was sutured with interrupted silk sutures to the outer surface of the superior flap of the divided pectoral muscle, thus overlapping the first row of sutures. An air-tight closure was secured by this method of overlapping. The subcutaneous tissue was closed with interrupted silk, and the skin with a continuous suture of steel wire. Steel as a skin suture is desirable because it causes less reaction around stitch-holes than any other type of suture. An uneventful recovery followed, and the patient was transferred to a convalescent hospital on June 1.

Case 12, age 21, was struck on November 13, 1942, by shell fragments in the right chest posteriorly, in the left thigh and in the right hip. There was marked dyspnea and hemoptysis on two occasions on the day of injury. Plasma and tetanus toxoid were administered immediately, and sulfathiazole (quantity not stated) was given the following day. A roentgenogram on November 15 revealed a fractured 8th rib posteriorly, a small right hemopneumothorax, and a foreign body, 2 cm in diameter, lying in about the center of the right upper lung field. He entered Mare Island Naval Hospital on January 30, 1943, with all wounds healed. Following leave, during which time he was operated upon for a ruptured appendix, he returned to the hospital in April complaining of discomfort in the right chest. Roentgenographically, the chest was clear except for the foreign body. Accordingly, the chest was opened through the second interspace anterolaterally. Numerous filmy adhesions between the visceral and parietal pleurae were carefully retained to avoid collapse of the lung. Palpation revealed the foreign body about 2 cm below the surface of the upper lobe laterally under the second rib. Two traction sutures were placed in the slightly fibrotic lung and the lung incised between them. No attempt was made to control the bleeding that occurred except by digital pressure. The foreign body was removed from a fibrous-lined cavity, the cavity curetted for other foreign material, sulfonamides introduced, and the incision in the lung closed by a deeply placed, right-angled lock-stitch of chromic catgut on an atraumatic or swedged needle. The lung was inflated, and there was no escape of blood or air as tested by water dripping over the line of incision. The operative wound in the chest was closed exactly as described in Case 11. There was no postoperative subcutaneous emphysema, and the patient was discharged to a convalescent hospital on June 1, perfectly healed. Roentgenograms showed a completely inflated lung without pneumothorax.

The foreign bodies disclosed by roentgenograms in two other cases (Figs



FIG 20 —Roentgenogram showing shrapnel fragment in right lower midchest which has not been removed because of absence of symptoms The empyema is cured

20 and 21) were not removed because no symptoms accompanied their presence in the lung

FOREIGN BODIES IN THE HEART

In 1939, Decker⁶ made a thorough and complete review of the subject of foreign bodies in the heart and pericardium with a statistical analysis of 100 cases, 47 of which were operated upon, with a mortality of 17 per cent, and 53 of which were not operated upon, with a mortality of 30 per cent. Surgical opinion favors nonintervention when foreign bodies in the heart produce no symptoms. Some interesting and instructive experiences await the surgeons of this war, as the following cases illustrate.

Case 13, age 21, was struck on December 7, 1941, by shrapnel in the right chest,

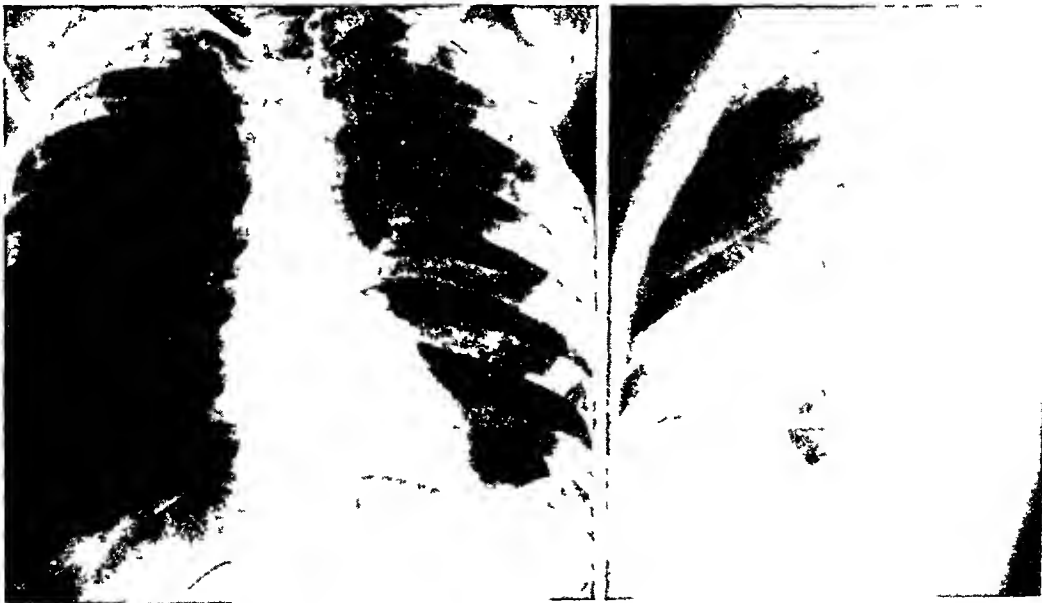


FIG 21 —Roentgenograms showing multiple small foreign bodies in chest which have not been removed because they are symptomless



FIG 22—Case 13 Foreign body within pericardium lying between the aorta and right auricle. The roentgenogram was interpreted as showing the foreign body in the lung. Fluoroscopy would have disclosed movement of fragment with each heart beat, thus locating it within the pericardium or within the heart.

the right elbow, and the right leg, followed by pains in the chest, difficult breathing, and dyspnea. Within two weeks all external wounds were well healed, and he had no complaints. On January 13, 1942, a roentgenogram (Fig 22) revealed a moderate hemothorax, and a jagged foreign body lying 2 cm to right of midline and about 3 cm inside the chest. The size, weight, and jagged character of the fragment were thought to warrant its removal.

On January 23, 1942, the right chest was opened through a short incision paralleling the sternum, a portion of the fourth rib and cartilage being excised



FIG 23—Case 13. The small circle marks the healed wound of entrance of shrapnel fragment that lodged within the pericardium at the base of the heart. The fragment was removed through a parasternal incision on January 23, 1942, the injury having occurred on December 7, 1941.

(Fig 23). On opening the pleura no free fluid was encountered, but widespread filmy adhesions were found between the lower lobe and the parietal pleura. Palpation of the lung did not disclose any foreign body, and it was at once apparent that the trail of the shrapnel fragment led toward the heart, where it could be palpated within the pericardium. A large circular defect was seen in the right lateral surface of the midpericardium, about 2 cm in diameter, filled with fibrinous exudate. This was enlarged toward the base, disclosing the origin of the aorta with a mass of fibrinous exudate overlying it, in which was embedded the foreign body. It appeared to lie at the base of the heart immediately between the aorta and the right auricle. The channel of entrance was enlarged by spreading it with a clamp. The fragment of shrapnel was withdrawn with considerable apprehension lest its removal be followed by bleeding. None occurred. A culture of the bed was taken, which subsequently proved sterile. One gram of sulfanilamide was placed in the pocket from which the piece of

shrapnel was removed. The short, three-centimeter incision in the pericardium was not closed, so that any inflammatory fluid might escape into the pleural cavity instead of accumulating in the closed pericardium, thus producing a cardiac tamponade. The wound in the chest wall was closed in layers with cotton sutures, and an air-tight closure was obtained, followed by primary healing.

The postoperative course was uneventful except for several episodes of paroxysmal tachycardia accompanied by marked dyspnea, promptly relieved by an oxygen tent. He was discharged to duty, February 14, 1942, but three days later, he was readmitted with a temperature of 101° F, pulse 110-140, respirations 30, and pains in the right lower chest. Under simple bed rest and sulfathiazole all signs and symptoms slowly disappeared, and he was subsequently discharged to full duty.

Case 14, age 25, was wounded on December 7, 1941, by what subsequently proved to be a machine gun bullet, which entered the left chest posteriorly through a small inconsequential wound which healed in five days. There was no wound of exit, but a roentgenogram on December 10 failed to disclose any foreign body. He was returned to sea duty on the 8th day following the injury, but he soon noted attacks of faintness and dizziness, accompanied by sudden and momentary blacking out of vision, occurring with or without exertion, but particularly on climbing the ship's ladders, or when rising

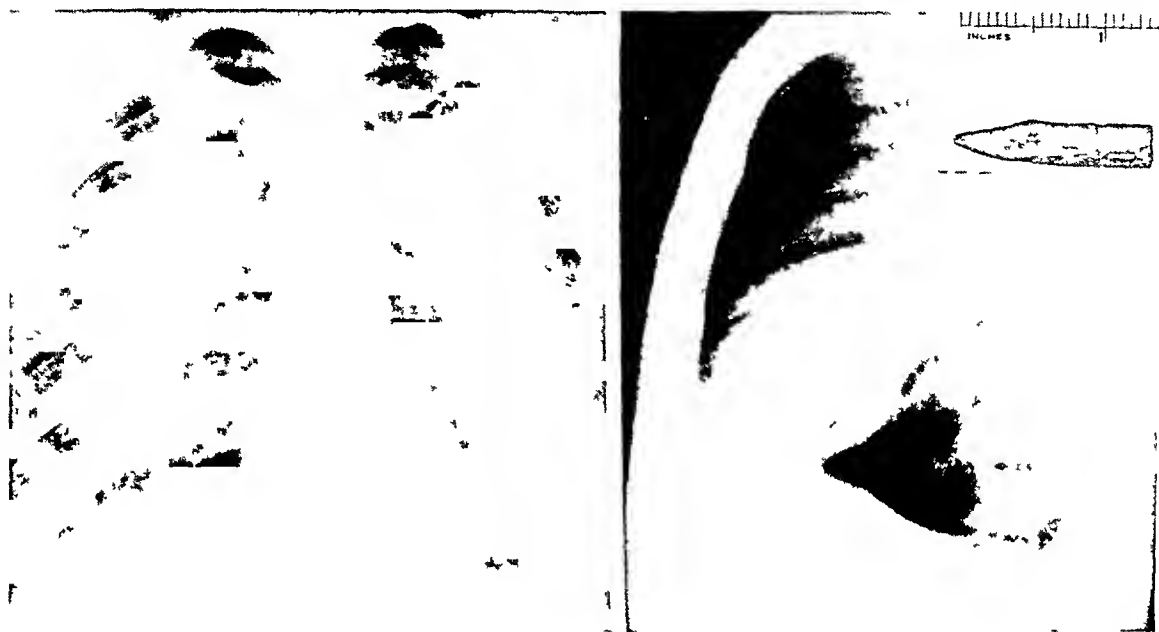


FIG. 24—Case 14. Roentgenograms showing bullet (insert) imbedded in what subsequently proved to be the interventricular septum about 0.8 cm. below the surface of the myocardium. Injury occurred December 7, 1941. Bullet removed April 17, 1942.

suddenly from a sitting or stooping position. He remained on duty for 35 days, when he was transferred to the sick-bay of a destroyer tender with symptoms of nervousness, lack of appetite, loss of weight, increased sweating, and dizziness on standing up suddenly. He also experienced palpitations of the heart, dropped beats, and extra systoles. Physical examination was negative at that time, and his pulse and blood pressure were recorded as "normal." A diagnosis of "psychoneurosis and hysteria" was made and he was returned to duty.

However, he was unable to do his work and was transferred to another destroyer tender, where he had an attack of appendicitis for which he was operated upon at sea. Blood pressure on this occasion was recorded as 112/72. During convalescence, a roentgenogram was taken on March 7, 1942, disclosing a bullet in the heart. The radiologist's report follows:

"Fluoroscopy and films of the heart reveal the bullet to describe a dancing rotatory movement with each cardiac pulsation, the motion of the posterior end of the bullet being of slightly greater amplitude than its tip. With each pulsation it also moves upward toward the base about one-half centimeter. In all postures, right and left lateral, recumbent, prone, supine, oblique and exaggerated Trendelenburg, there is no shifting of position of the bullet, but the motions, synchronous with the heart

beats, remain constant. The size and contour of the heart are normal, and there is no evidence of free fluid in the pericardial sac, neither is there any residual evidence of pulmonary injury. The position and behavior of the bullet leads to the conclusion that it is at least partially imbedded in the myocardial muscle near the apex."

On admission to Mare Island Naval Hospital on March 30, 1942, he still complained of dyspnea on exertion, dizziness on assuming the erect posture suddenly, occasional sharp pains in the left chest, dropped beats and extra systoles. His color and nourishment were normal, temperature 98.6° F, pulse 88, respirations 18, blood pressure 110/70. There was a small oval healed scar on the posterior left thoracic wall, 3 cm below the angle of the scapula. The heart was not enlarged. There was no murmur or friction rub to be heard, and the electrocardiogram was normal. A roentgenogram (Fig 24) was interpreted as showing the bullet in the interventricular septum, in the region of the apex.

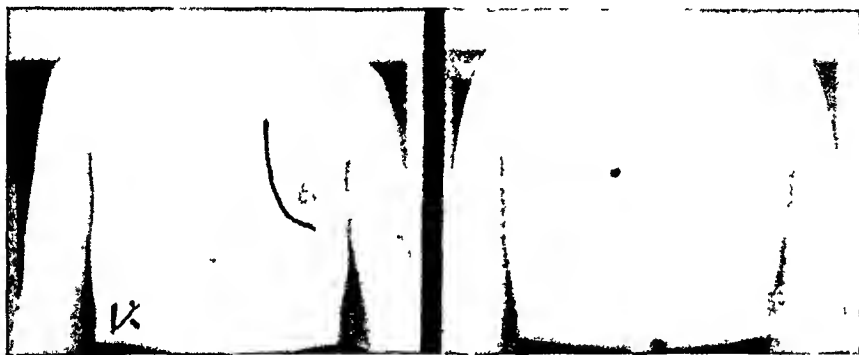


FIG 25—Case 14. Heart was approached through a curved incision, 8 cm of 4th rib, and costal cartilages of 3rd and 5th ribs were removed. Pleural cavity was not entered. Dot on back shows healed wound of entrance of bullet which lodged in the heart.

On April 17, 1942, the bullet was removed. A curved incision was made to the left of the midline (Fig 25). About 8 cm of the 4th rib were removed together with its costal cartilage and the costal cartilages of the third and fifth ribs. The pleural cavity was not entered at any time during the operation. The pericardium, which appeared normal, was incised between two previously placed sutures. There were no adhesions, nor fluid in the anterior pericardial sac. In the midportion of the exposed anterior surface of the heart directly over the interventricular septum, was a round, discrete, elevated button of pink fibrous tissue 2.5 cm in diameter, surmounted by a glistening endothelium, in the center of which could be felt the tip of the bullet lying about 8 mm below the surface. The nubbin of fibrous myocardium was incised between traction sutures of cotton. The bullet lay encased in a tough fibrous wall about 1.5 mm thick. This was incised and the bullet grasped with an Allis clamp. Traction on the forceps lifted the heart completely out of its bed, but failed to dislodge the bullet. Tugging on the bullet produced extreme irregularities in cardiac action. Several rather vigorous attempts at removal were unsuccessful. These difficulties were then surmised to be due to the creation of a vacuum behind the bullet. Accordingly, a grooved director was passed alongside the bullet, admitting air back of it, followed by prompt and easy removal. There was no bleeding. Sulfathiazole was introduced into the cavity from which the bullet had been removed, and the fibrous myocardium was closed with four interrupted cotton sutures. The pericardium was incompletely and loosely closed with two sutures so as to permit any blood or inflammatory fluid to escape into the mediastinum, thus avoiding the development of a cardiac tamponade. The wound in the chest wall was closed in layers with cotton sutures, without drainage.

An electrocardiogram, taken on the day of operation, instead of being normal as before, showed a sinus tachycardia, T1 was lower, and T2 had a late inversion.

WOUNDS OF THE CHEST

On the day following operation the pulse was 105, and an electrocardiogram showed that T₁ and T₂ had become elevated. The conduction times were normal and unchanged. The T-wave changes were those seen with anterior myocardial abnormalities. The S-T intervals resembled those produced by pericarditis. On April 21 the electrocardiogram was again normal.

It was confidently hoped that this patient would be able to return to combat duty, but the symptoms of a war neurosis persisted, and it was necessary to discharge him from the service. However, at the present time he is without symptoms, has married, and is doing a full day's work in an aeroplane factory.

DISCUSSION AND SUMMARY

In 36 cases of gunshot wounds of the chest, 20 showed marked dyspnea, 16 hemoptysis, usually of very mild degree, 19 hemothorax, of which 12 were aspirated for a total of 27 times, 3 cases of aspiration were accompanied by replacement with air, 2 of which were complicated by empyema, 7 cases of hemothorax were not aspirated, followed by uncomplicated recovery, 8 cases had retained foreign bodies, in 5 of which they were removed, 8 had fractured ribs, for which no particular treatment was necessary, 6 had sucking wounds, requiring early closure, and 6 were complicated by empyema, 2 of which will require a thoracoplasty for cure. There were no deaths in the cases evacuated to the mainland from the South Pacific area.

The following principles underlie the treatment of thoracic injuries.

Clean-cut bullet wounds without symptoms require simple dressing only.

Jagged dirty wounds of entrance and exit should be excised immediately when possible, or filled with sulfonamide powder and excised later when the opportunity presents, if the wound is still free of pus.

Large sucking wounds of the chest must be closed, but such closure may tax one's ingenuity to the utmost. At the time of injury, if operative closure is not immediately possible, the wound or defect may be covered with a sterile rubber glove, or filled with sterile vaselined gauze, covered with a voluminous dressing, and fixed in place with a large adhesive bandage encircling the chest. This will produce fixation of the mediastinum which will permit the thoracoplastic procedures which later may be found necessary to close the defect.

Immediate available operative measures are:

Semilunar, relaxing incisions in the muscle layers either on one or both sides of the defect may permit closure of the muscles without tension.

Semilunar, relaxing incisions in the skin on one or both sides of the defect may permit closure of the defect. The resulting raw surfaces, away from the defect, may later be skin-grafted.

Resection of one or two ribs on one or both sides of the defect may permit sufficient mobilization of the soft parts to bring the tissues together without tension.

The liberal use of sulfonamides locally and orally is indicated in all instances. In case of gross contamination of the pleural cavity by dirt or clothing, drainage is indicated by air-tight catheter introduced through an intercostal space well separated from the closed wound.

Hemothorax is a frequent complication of gunshot wounds, but surprisingly often is not infected, and may be reabsorbed. The mere presence of a hemothorax warrants neither operation nor aspiration. Aspiration may be limited to cases showing respiratory embarrassment, to cases suspected of having a complicating infection, and to cases in which blood or fluid fails to be reabsorbed after two or three weeks. Increasing dyspnea in the first two or three days after injury may be evidence of continued bleeding. If degree of dyspnea and mediastinal shift demand it, aspirate as much blood as may be necessary to relieve but not to eliminate entirely the dyspnea, which must be controlled partially by morphine. The aspiration of a large volume of blood at one time is contraindicated as the sudden reexpansion of the lung may reactivate the bleeding. If dyspnea recurs promptly after simple aspiration, an attempt may then be made to secure relief through aspiration and replacement with air. Prompt recurrence of dyspnea after such an attempt demands thoracotomy for the control of the bleeding vessels. Before undertaking a thoracotomy to stop bleeding, massive transfusions must be available for immediate use.

A hemothorax or serosanguineous effusion that persists beyond two or three weeks without diminution may be aspirated, but replacement with air at this late date is not necessary. Thin, bloody fluid is evidence that bleeding has ceased, and that air replacement is unnecessary. Air replacement may be highly detrimental to prompt healing should an empyema develop in the presence of the pneumothorax. Extensive thoracoplastic procedures may be the penalty for unnecessary or ill-advised replacement with air.

Wounds of the lung do not require operative intervention *per se*, unless uncontrollable hemothorax or uncontrollable tension pneumothorax demand it. The removal of foreign bodies in the chest may be safely postponed in most instances until ideal conditions prevail. Positive pressure or intratracheal anesthesia should be available and exact localization of the foreign body by fluoroscopy should precede any attempts at removal, if the embarrassment of failure is to be avoided. Small, symptomless foreign bodies may be allowed to be retained without harm.

Linear wounds produced by débridement or simple incisions in the lung for removal of foreign bodies may be closed with deeply placed right-angled lock-stitch sutures of catgut on atraumatic needles. Leakage of air as demonstrated by dripping water over the line of suture must be controlled by reinforcing sutures.

Incisions in the myocardium may be closed with interrupted silk or cotton sutures. Following operations upon the heart, the pericardium should be closed very loosely with widely spaced interrupted sutures so as to permit escape of blood or inflammatory fluid that might, if retained within the pericardium, produce a cardiac tamponade.

Exploratory thoracotomy can usually be performed through intercostal incisions without rib division or rib excision if a suitable self-retaining rib spreader is available. When thoracotomy for the removal of foreign bodies

is performed, every effort should be made to avoid or limit the division of adhesions between the visceral and parietal pleurae in order to avoid unnecessary collapse of the lung. Such thoracotomy incisions may be closed air-tight by (1) pericostal sutures of doubled chromic catgut to approximate the ribs, (2) suturing superior edge of divided chest wall muscle to inferior edge of divided intercostal musculature, and (3) suturing inferior edge of divided chest wall muscle to outer surface of the superior flap of divided chest wall muscle, thus overlapping the first line of sutures. Interrupted sutures of silk or cotton should be used throughout. Continuous steel suture in the skin is preferable when available because of its nonirritating quality. Drainage is indicated only in the presence of marked soiling, as when thoracotomy is performed immediately following injury. Drainage by catheter connected with an underwater seal through an intercostal space independent of the thoracotomy wound is indicated.

Empyema developing in the first two to three weeks after injury should be drained by air-tight catheter rather than by resection of rib or intercostal incision, if at all possible, in order to avoid collapse of lung. Repeated aspirations and microscopic examination of the aspirated fluid will permit an early diagnosis of developing empyema when such catheter drainage can still be made effective.

Reexpansion of collapsed lung may be greatly accelerated by "forced expiratory exercises." The patient inspires deeply and then forcibly expires against a closed nose and closed mouth. Its effectiveness to produce expansion of the lung is easily demonstrated in the presence of a draining empyema by the escape of retained fluid when forced expiration is performed. In the presence of an empyema cavity or a pneumothorax, the patient is required to execute the forced expiratory exercises as often as every hour during the day. They may not be instituted in the presence of an open bronchial fistula.

Following traumatic lesions of the chest involving lacerations of the lung a prolonged convalescence is indicated. Return to duty should be postponed until roentgenographic evidence of intrapulmonary damage has largely disappeared and is minimal.

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AFFERENT VASODEPRESSOR NERVE IMPULSES AS A CAUSE OF SHOCK TESTED EXPERIMENTALLY BY AORTIC-DEPRESSOR NERVE STIMULATION*

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ONE of the oldest theories of shock accompanying injury by either accidental or militant violence or by surgery is that it may result from an insult to the nervous system. The most prevalent conception of the mechanism is that excessive afferent depressor nerve impulses are set up either in the wound or in the cerebrum which act upon the vasomotor center, and to a lesser extent upon the cardiac center in the medulla, causing a fall in blood pressure of such magnitude and duration that the circulation becomes inadequate, the tissues are damaged and the bodily functions are impaired. The prolongation of such a state is thought to result in complete circulatory failure and death. The term "primary shock" has been widely used to denote a condition presumably produced in this way. The mechanism has also been considered as a contributing factor where other causes, as hemorrhage, are primary. Most of the members of the medical profession attach some importance to the theory and it is discussed with varying degrees of favor in nearly all textbooks of surgery and physiology. Crile¹ was for many years the chief exponent and the American Red Cross First Aid Book² gives this in simpler terms as the mechanism of shock production. Any theory of shock that receives this amount of credence is worthy of careful analysis as to its merits.

Before considering the effects of afferent depressor nerve impulses, it is well to review briefly the more important influences of the nervous system on the blood vessels and heart. Control of the blood vessels is exercised principally through the vasomotor center in the medulla as shown schematically in Figure 1. Efferent impulses pass from it by pathways in the spinal cord to the sympathetic and parasympathetic systems, and in case of vasodilators to a limited extent to the somatic nerves (antidromic fibers), and thence to the vascular system. They are both vasoconstrictor and vasodilator but the former predominate in the lowering of general blood pressure as proven by the fall of blood pressure to shock levels after section of the spinal cord at C-8. Afferent impulses pass to the vasomotor center by way of the somatic and aortic-depressor (or cardio-aortic) and carotid sinus nerves and from the cerebral cortex. Both pressor and depressor afferent impulses

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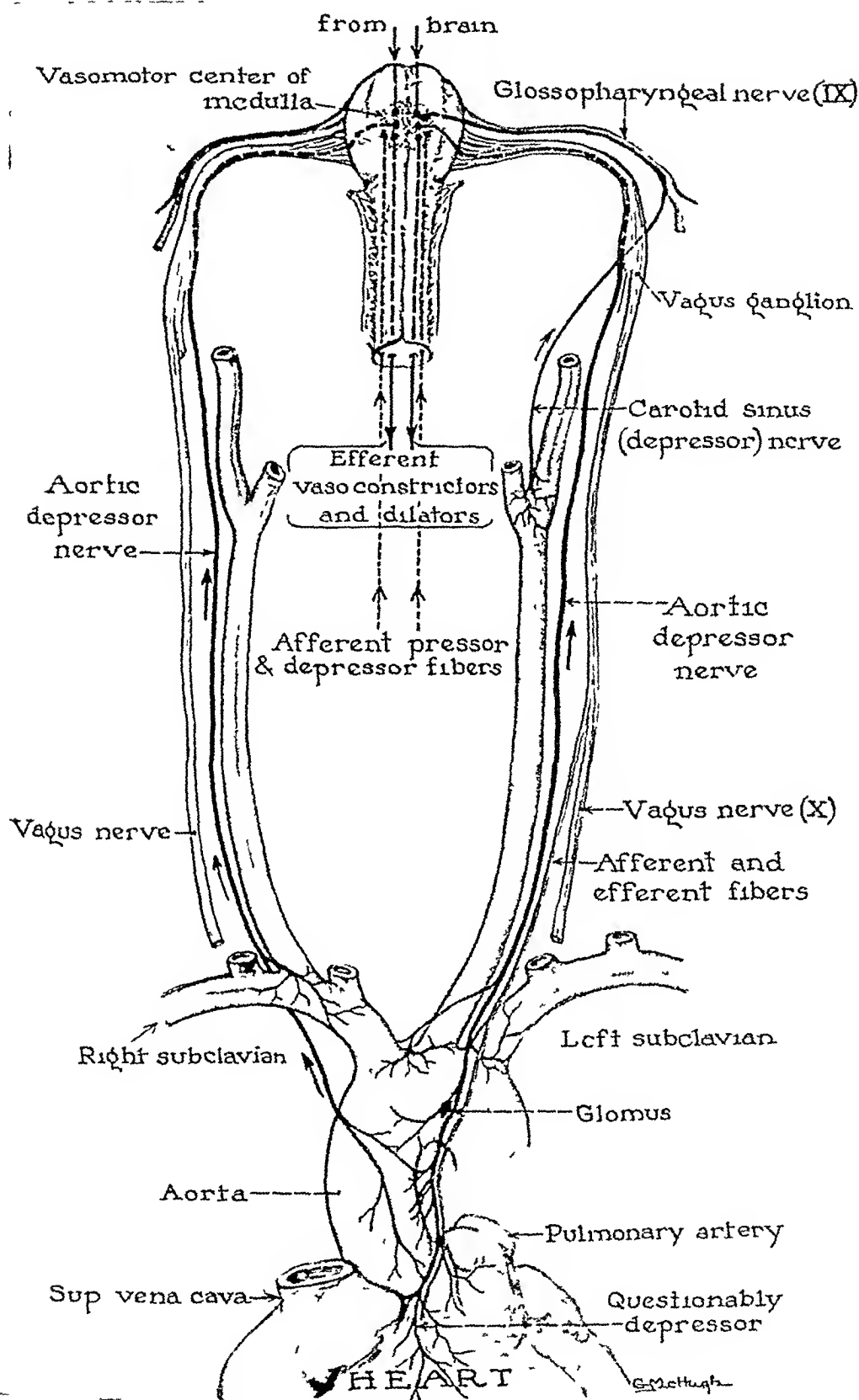


FIG 1—Schema of carotid sinus and aortic depressor nerves and of principal afferent and efferent medullary pathways

come over the somatic nerves having separate pathways in the spinal cord, as shown by Ranson and Billingsley,³ and over pathways from the cerebral cortex. However, only depressor impulses come to the medulla over the aortic-depressor and carotid sinus nerves making them particularly favorable structures for isolation and stimulation in an experimental study of the effects of vasodepression from afferent impulses. The aortic-depressor fibers are found as separate nerves in the neck only in the rabbit and in a certain percentage of cats, being fused with the vagi in all other animals.

Nervous control of the heart is by efferent inhibitor impulses from the medulla over the vagi, by efferent accelerator impulses from the upper thoracic cord and to some extent from higher centers, passing over the sympathetic cardiac nerves, and by afferent impulses over fibers in much the same pathways to the medulla as are afferent impulses affecting the blood vessels.

The blood pressure is modulated reflexly by the maintenance of a balance between vasopressor and vasodepressor impulses and to a lesser extent between cardio-inhibitor and cardio-accelerator impulses (Heymans⁴). There is a continuous flow of vasopressor or constrictor impulses from the medulla over the sympathetic nerves which act in the direction of elevating the blood pressure. There is also a continuous flow of proprioceptive depressor impulses from the aortic arch over the aortic-depressor nerves and from the carotid sinuses over the carotid sinus nerves which act in the direction of lowering the blood pressure. Some investigators, as Heymans⁴ and Daly and Verney,⁵ maintain that afferent depressor fibers from the heart also join the aortic-depressor fibers to form a single nerve in the rabbit or a bundle fused with the vagus in other animals. Within prescribed limits any increase in pressure in the vessels supplied by these nerves stimulates their endings and augments their impulses (Bronk and Stella⁶), which inhibit the vasoconstrictor and stimulate the vasodilator centers in the medulla causing a decline in general blood pressure. Conversely, any decrease in pressure within the same vessels retards these nerve impulses, thereby lessening the inhibition of vasoconstrictor and the stimulation of vasodilator impulses, and resulting in a rise in general blood pressure.

Afferent (exteroceptive) impulses, both pressor and depressor, coming directly to the medulla by way of the somatic nerves appear under normal conditions to produce little more than fleeting alterations in general blood pressure and play relatively little part in its modulation. Impulses from the brain may play a more important rôle.

From the clinical standpoint, if traumatic shock is ever produced by hyperactivity of afferent depressor impulses on medullary centers, the impulses reach the medulla either by way of somatic nerves directly from the injured field or from the cerebrum where they may be set up by distressing special sense perceptions as the sight of blood or of the injured field, or by pain perception. The low blood pressure in syncope is a manifestation of such cerebral activity. The aortic-depressor and carotid sinus (proprioceptive)

nerves, although the most effective vasodepressor nerves, are obviously so small and so situated anatomically that they would never be directly injured and continuously stimulated to produce shock. Sudden reflex death, usually respiratory but possibly also cardiac, sometimes occurred during dissection of the carotid sinuses in dogs when they were being prepared in a set of stimulation experiments but reflex death was never encountered in the aortic-depressor nerve experiments. The cause of the prompt lowering of blood pressure that is sometimes observed during manipulations within the abdomen of man is imperfectly understood. It appears to result from reflex vasodepression and there is associated cardiac inhibition. Whether the afferent impulses travel by way of proprioceptive fibers of abdominal blood vessels that may be contained in the vagi or by way of somatic or sympathetic nerves remains to be clarified.

From the experimental standpoint, the three possible ways of attempting the production of shock by hyperactivity of afferent depressor impulses on centers in the medulla are by stimulation, first, of the trunks or receptors of the somatic nerves, second, of the proprioceptive aortic-depressor and carotid sinus nerves, and third, of the depressor centers of the cerebral cortex. The effects of the lowered blood pressure should be the same by whichever method produced, provided the degree and duration of the lowering and the anesthesia and trauma associated with the experiment were the same.

It appears that no attempt has been made to stimulate the depressor centers of the cerebral cortex with the intention of producing shock, but judging by the results of stimulation reported by Hoff and Green,⁷ Schafer,⁸ and others, in certain animals, the prospects for success with existing techniques are unfavorable since the fall in blood pressure was relatively brief and slight.

By far the simplest and most efficient way of producing marked and prolonged lowering of blood pressure by hyperactivity of afferent vasodepressor impulses is through stimulation of the aortic-depressor (cardio-aortic) nerves in rabbits. The results achieved by Phemister and Schachter⁹ by stimulation of the carotid sinuses in dogs were similar to but less marked than those to be reported here for the aortic depressor nerves. They are very small structures lying back of the common carotid arteries and just mesial to, and parallel with, the slightly larger cervical sympathetic chains. Their endings are in the arch of the aorta and some authors still claim, in the heart. Several animals were dissected for cardiac fibers in this series and none found.

EXPERIMENTAL METHODS

Because of the unusual sensitiveness of the rabbit to anesthesia, the very small size of the aortic-depressor nerves and the delicacy of the femoral arteries for cannulation, it was found necessary to work only with large animals such as the Flemish Giant breed. With few exceptions, the successful results were obtained with animals weighing from 4 to 6 Kg. The circulating blood volume

derived by the Evans blue dye method on 17 animals averaged 68 per cent of the body weight. The average amount of blood obtained (bleeding volume) by bleeding 10 rabbits to death under urethane anesthesia was 48.5 per cent of the calculated blood volume. Average blood analyses in rabbits were as follows: For 100 animals, R B C 613, Hb 80.8, Hcr 37.5, 50 animals, arterial blood oxygen 6.74 Mm/L and CO₂ 17.71 Mm/L, 29 animals, plasma proteins 5.88 Gm per cent. Blood losses from surgery and cannula clot washings were calculated in most cases with the aid of the Evelyn colorimeter from determinations of hemoglobin removed from the sponges and wash basins.

Anesthesia was produced by urethane administered intraperitoneally. After experience with doses 25 to 100 per cent larger, it was found that the most satisfactory results were obtained with 500 mg per Kg body weight. In animals not experimented upon the anesthesia wore off in three to four hours. A small amount of ether was sometimes added during surgery in case the animal was noisy.

The animal was placed on its back on a dog board and the extremities anchored with cords. The front limbs were held against the sides by passing the cords behind the back and over the front of the opposite forelegs before tying them together beneath the board. A heavy ligature was passed around the symphysis of the mandible with a curved needle. The bit of the head piece of the dog board was then passed between the teeth and the mandible was tied firmly to it.

The femoral arteries were then exposed below Poupart's ligament, the branches tied off and cannulae made from No. 16- to 18-gauge needles inserted for obtaining blood samples on one side and for kymographic recording of blood pressure on the other. A blood sample was usually drawn at this time.

The nerves were then isolated through a midline incision from the larynx to the sternum. The carotid sheath was exposed on either side by separation of the overlying neck muscles. With a toothless forceps, the carotid artery was lifted slightly forward and mesialward by an assistant, while the operator displaced the vagus lateralward and backward. This brought into view the two small nerves closely approximated and held loosely together by fibers of the carotid sheath. The mesial trunk, which is usually the smaller, is the aortic-depressor nerve while the lateral is the cervical sympathetic trunk. Beginning below, they were separated and freed with care by use of fine dissecting instruments, after which threads were passed about them for retraction. Despite these precautions, injury was common and many experiments were spoiled in this way. The left aortic-depressor nerve usually appeared to be slightly larger than the right and often gave a greater response on stimulation.

The cannula of one femoral artery was next connected with the kymograph tubing system and the blood pressure recording was begun.

A shield electrode was placed on the trunk that was considered to be the aortic-depressor nerve on either side and each nerve tested for blood pressure response. The Harvard inductoriums were activated by alternating

current received from a six-volt transformer. If the pressure failed to fall on appropriate stimulation, it usually meant either injury to the nerve or that the sympathetic was being stimulated by mistake in which event there was usually a slight rise in pressure.

TYPES OF EXPERIMENTS

The effects produced by stimulation of the aortic-depressor nerves on blood pressure (pulse, respiration, blood cytology, blood chemistry, survival time, and gross and microscopic anatomy) have been determined in varying degrees of completeness according to the stage of development of the work and the available facilities. Factors that have sometimes modified the results adversely have been trauma to tissues and blood loss incident to the operation, withdrawal of blood samples, blood loss from cannula washings, the anticoagulant employed and hot weather. Samples consisted of 4.5 cc of arterial blood when red cell, hemoglobin, hematocrit, plasma proteins, oxygen and carbon dioxide determinations were made and of one cc when only the first three were made. Sodium citrate which was used as the anticoagulant in the cannula in all rabbits up to No. 98 produced slight toxicity in some cases and there was more blood loss from cannula clotting and washing than occurred with saline and heparin, which was used in all rabbits above this number. Rabbits tolerated the experiments very poorly during the hot days of summer, often developing a low blood pressure and dying relatively early without stimulation, so that all experiments done at that time had to be discarded.

Interference with stimulus has resulted not only from traumatism to the nerves during isolation but also from drying and from leakage of current due to accumulation of fluid in the wound and contact with surrounding muscles. The electrodes were usually brought into the subcutaneous region and the skin clamped about them. At the onset of recording on the kymograph, the blood pressure was found to range between 80 and 120 Mm Hg, the average for 100 rabbits being 103 Mm. The pulse was then found to be usually above 200 per minute and rarely lower than 160. The respirations ranged between 40 and 80 per minute.

In control experiments the set-up was as described here but no stimulus was applied to the nerves. The results in three cases are shown in Table I. The average survival time was 14.66 hours. The blood pressure was well preserved until relatively late in two experiments and declined more gradually in one. Hemodilution developed in all cases. Figure 2 shows a condensed tracing of blood pressure with the pulse and respiration rates, and Table II the blood findings, of Experiment 78, in which the survival time was 18.5 hours. Blood loss throughout the course of the experiment from repeated cannula washings and sample withdrawals was unusually high, amounting to 26 per cent of the calculated blood volume, but despite this fact, the blood pressure remained above a shock level until one hour before death. Micro-

scopic examination of sections of tissues showed slight acute degenerative changes in the viscera

TABLE I
CONTROL RABBITS FOR AORTIC-DEPRESSOR NERVE STIMULATION EXPERIMENTS

Exp No	Wt Kg	Urethane mg /Kg	Survival Time	Initial Pressure Mm Hg	Pressure Levels and Time Elapsed from Start	Blood Changes			
						Time	Hcr %	Hb Gm	R B C M
46	4 4	500	13 hrs	90	70 to 100 in 4 hrs 100 to 80 in 8 hrs	Initial	29	10 7	4 98
57	4 4	500	12 5 hrs	80	80 to 0 in 1 hr	Final	20	8 2	3 16
					80 to 50 in 12 5 hrs	Initial	37	13 6	5 92
78	4 7	500	18 5 hrs	110	110 to 100 in 16 hrs	Initial	36	13 1	6 94
					100 to 66 in 2 hrs	Final	32	12 4	5 30
					66 to 0 in 0 5 hr	Final	27	8 8	4 60
Average survival			14 66 hrs						

TABLE II
RABBIT NO 78 (FIG 2)

Time Hrs	R B C		Hb	Hcr
	M		Gm	%
0	6 94		11 9	36
2 0	6 80		11 7	36
5 5	5 66		10 4	31
9 0	5 10		9 6	30
13 0	5 58		9 8	31
18 0	4 60		8 1	27

EFFECTS OF STIMULATION

Various effects of lowering the blood pressure to different levels for different but substantial lengths of time by nerve stimulation were studied in a series of 28 rabbits in which the circulation had not been disturbed otherwise than by the set-up of the experiment. A brief account of the findings has been reported by one of us (D B Pheemister¹⁰)

Under favorable experimental conditions, the blood pressure was reduced in the course of two or three minutes to low levels and the heart slowed to 60 to 100 beats per minute by stimulation of both nerves with the secondary coils placed 8 to 10 cm from the primary coils. Under continued stimulation, the pressure might remain low for long periods of time without increase of the strength of the stimulus or it might rise gradually, necessitating periodic increases in strength to keep it down. When one nerve only was stimulated, the blood pressure remained at a higher level than when both were utilized and a stronger stimulus had to be applied to attain a low level. After the initial bradycardia, the pulse rate increased during the next few minutes but usually remained somewhat retarded as long as the stimulus was continued. Removal of the stimulus was followed by a rapid return of blood pressure to the vicinity of the previous level and by acceleration of the pulse rate. Respirations were little influenced directly by the stimulation. In many un-

Rabbit 78 Wt 4.66 Kg Urethane 2.33 Gm 1 p

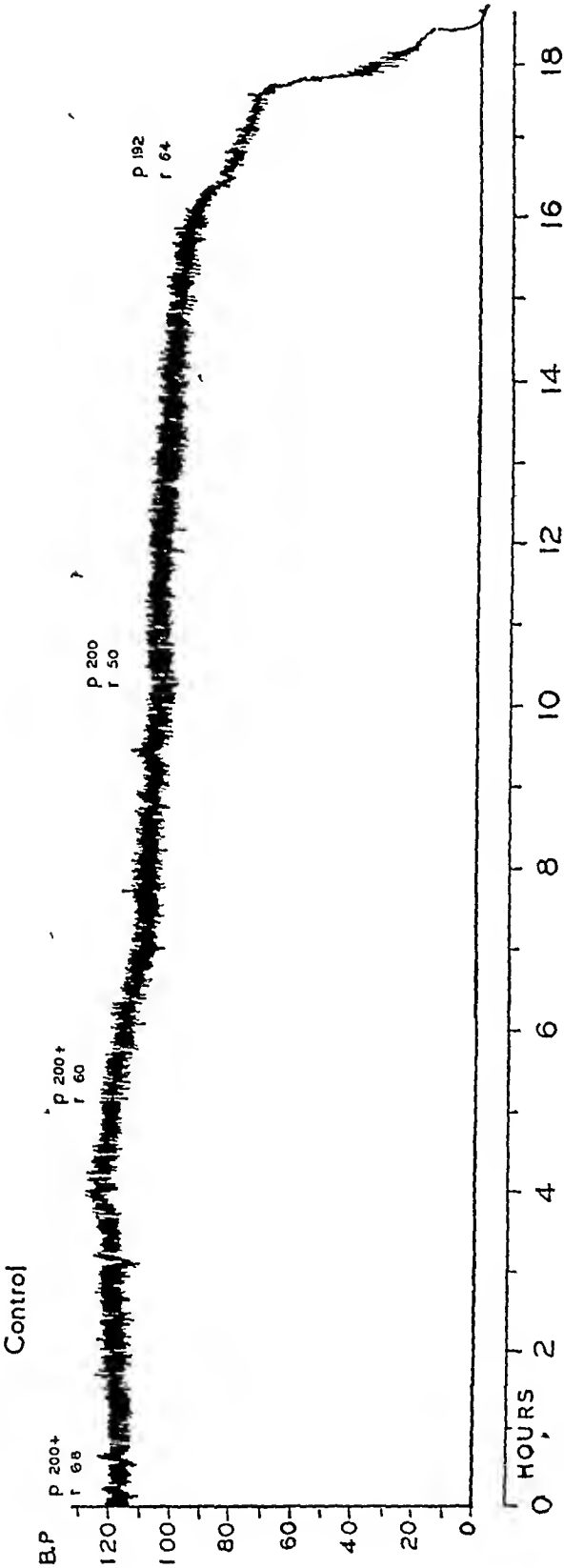


Fig 2--Condensed blood pressure tracing and pulse and respiration rates of control for aortic depressor nerve stimulation experiments

reported experiments it was impossible to reduce the blood pressure to a shock level or, if so, to hold it at the desired level for the necessary length of time regardless of the strength of the stimulus employed

Sometimes a relatively weak stimulus produced the maximum vaso-depressor effect as shown by the fact that a further increase in strength caused no more decline and in no case was it possible to produce sudden death of the animal by applying the maximum stimuli carried by the two inductariums. These changes are illustrated in Figure 3, Rabbit 122. At the beginning of the recording the blood pressure was 115 Mm Hg and the pulse was over 200. With the secondary coil at 9 cm, first the right and then the left cardio-aortic nerves were stimulated, the fall in blood pressure being slightly greater from the left than from the right nerve. After a four-minute rest period, both nerves were stimulated and the blood pressure fell from 105 to 25 Mm Hg in 15 minutes, during which time the pulse dropped to about 60 beats per minute. The pressure then rose to 40 Mm during the next minute and the pulse increased to 96 per minute. The pressure soon declined to the vicinity of 30 Mm Hg where it remained for the rest of the half-hour period of continuous stimulation. The stimulus was then released for ten minutes, whereupon the blood pressure quickly returned to the vicinity of the previous level and the pulse increased to 180 per minute. Since the blood pressure was so rapidly reduced and maintained at such a low level by stimulation, with both secondary coils at nine cm, it was thought that using the maximum current from the inductariums, obtained by placing the secondary coils at the zero points, might cause either further lowering of pressure or death of the animal. However, when this was done, the blood pressure dropped quickly to the vicinity of the previous level, after which it slowly rose. The pulse was retarded, being 128 per minute after four minutes and 140 after 22 minutes, and the animal survived six hours of stimulation with short periods of interruption as will be reported later (Fig 11).

CONTINUOUS STIMULATION

In other experiments, the blood pressure would remain at higher levels but within the range which is encountered in well marked shock as produced by straight bleeding or by limb trauma. In the majority of cases of effective stimulation, the pressure could be kept at low levels for several hours during which period release of the stimulus would be followed by a prompt restoration of the pressure to, or slightly under, previous levels and by rapid recovery of the circulation. Reapplication of the stimulus would cause an immediate decline which for a few minutes usually went slightly lower than the previous depression. If stimulation continued to be effective, the blood pressure eventually tended to drift to a lower level and the pressor response on release gradually weakened until it became very slight or was exhausted and the animal died. Respirations were usually shallow toward the end. The survival period of six such animals under continuous stimulation, except

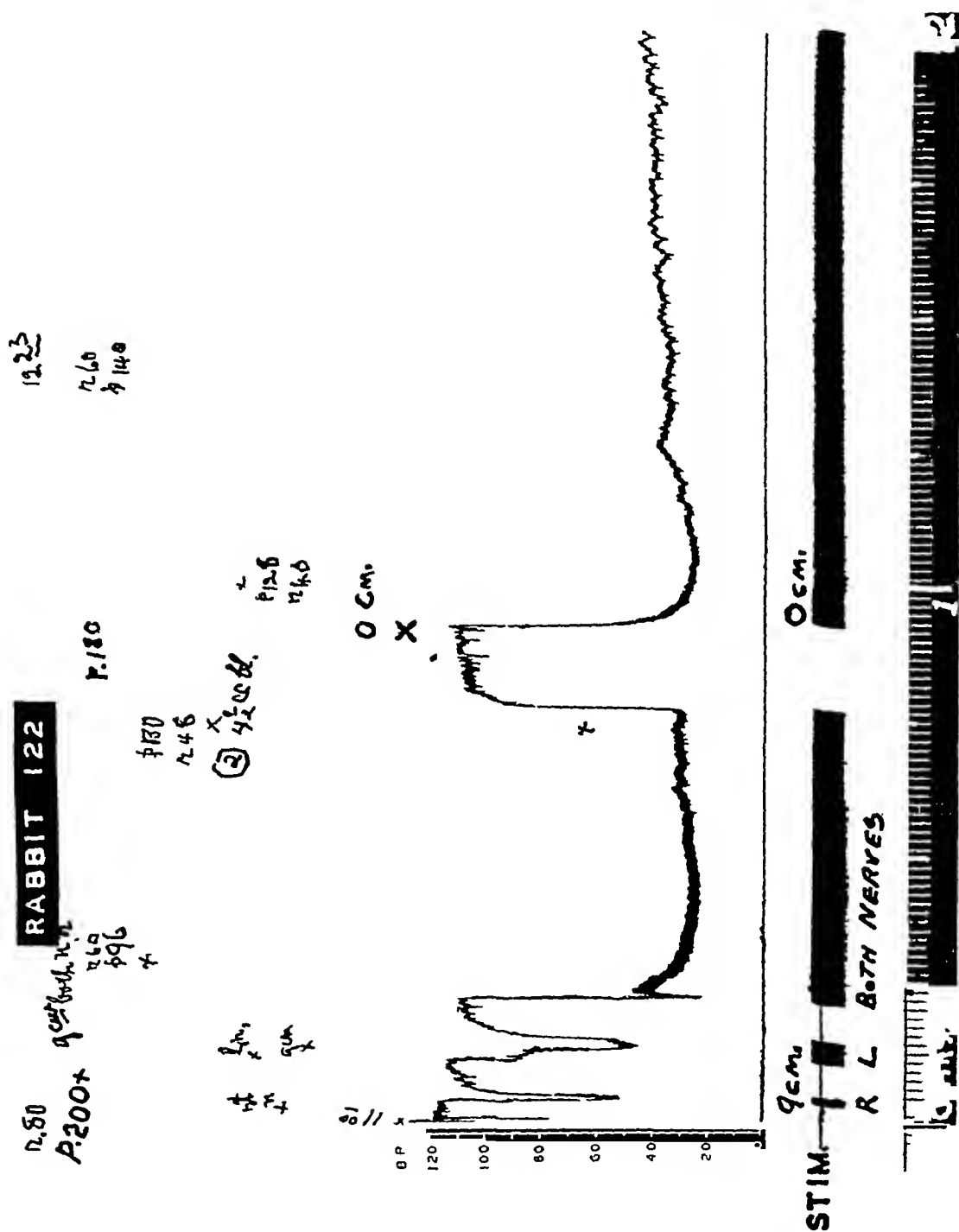


FIG. 3.—Showing comparison of visodepressor effects from a relatively weak and a very strong stimulus applied to the aortic depressor nerves of a rabbit

for the short test releases, varied from 2.5 to 13 hours for all ranges of shock level, averaging 6.75 hours. In general, there was a direct relationship between the level of the pressure and the length of survival, the lower the pressure and the smaller the pulse pressure, the shorter the survival time.

Figure 4, Rabbit 147, shows a condensed tracing of the shortest and most rapidly fatal experiment. At the beginning there was a low irregular pressure following stimulation of the right nerve with the secondary coil at

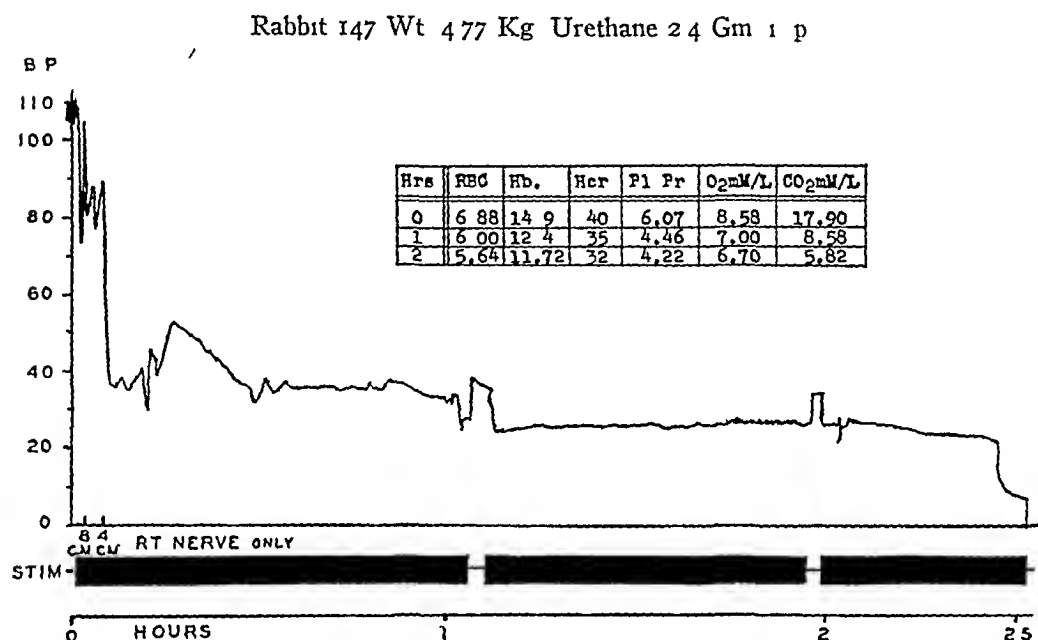


FIG. 4.—Changes in blood pressure and blood produced by aortic depressor nerve stimulation, early loss of vasoconstrictor tone and early death.

four cm. The pressure then steadily declined to 28 Mm Hg at the time of death 2.5 hours later. Release of the stimulus just beyond one hour and just short of two hours of the onset of stimulation showed very feeble rises of blood pressure. The blood loss was 14 cc from cannula wash and hemorrhage and 15 cc from samples, totaling 8.9 per cent of the estimated blood volume which was a factor of little importance in the causation of death. The blood analyses showed a steady severe reduction in red cells, hemoglobin, hematocrit, plasma proteins, oxygen and carbon dioxide of the arterial blood. The blood changes and the failure of the vasopressor center appeared to be the cause of the rapid death. Necropsy revealed no significant gross changes. Microscopic examination revealed moderate congestion of the lungs and kidneys and marked congestion with sinus dilatation of the spleen. Liver, adrenal, pancreas, heart and striated muscle showed no changes.

Figure 5, Rabbit 75, shows the more usual course where the blood pressure, except for a short rise after the initial fall due to leakage of current, stayed slightly under 40 Mm Hg for four hours, with each short release resulting in a prompt elevation to approximately the original level, indicating that the circulatory mechanism was still intact. Under continued stimulation the

pressure declined slowly and the pressor responses on release weakened rapidly until the animal died at the end of 5.5 hours. The stimulus was increased from 11 cm to eight cm during the first 5.5 hours and to six cm for the remaining period. Again the blood showed a steady reduction of red cells, hemoglobin, hematocrit, oxygen and carbon dioxide, except for an increase in the last carbon dioxide determination.

Rabbit 75 Wt 4.55 Kg Urethane 2.28 Gm 1 p

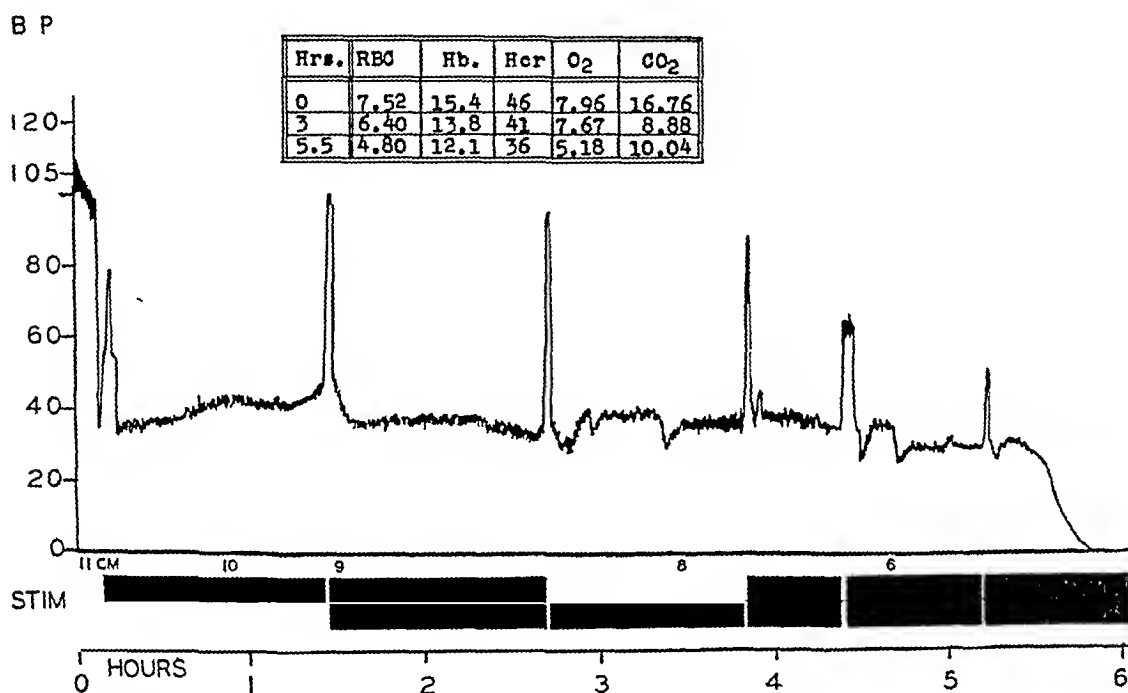


FIG 5—Blood pressure tracing showing vasodepression from aortic depressor nerve stimulation with progressive increase in stimulus strength, gradual loss of vasoconstrictor tone and hemodilution

Necropsy showed little gross evidence of change. Microscopic examination of pancreas, adrenal, heart and skeletal muscle revealed normal findings. The liver and lungs were moderately congested and the spleen markedly so. The liver showed acute focal necrosis. Scattered cells and clusters up to 25 cells revealed cell fragmentation and disintegration of nuclei (Fig 6). There were large lymph spaces in the folds of the duodenal lining.

Figure 7, Rabbit 54, illustrates a case in which the blood pressure remained around the relatively high level of 60 Mm Hg during the first three hours of stimulation with a weak current (nine to 11.5 cm). Response of pressure to release of the stimulus on two occasions was marked. After increasing the strength of the stimulus to 8.5 cm, the pressure declined gradually and the responses on release weakened for the next two hours. Then with the pressure at 40 Mm Hg, a rapid decline set in as if death were imminent, for which reason the stimulus was removed. The circulatory mechanism was so nearly exhausted that the pressure remained at or about 25 Mm Hg for five minutes before it gradually rose to 35 Mm. When the stimulus was re-applied at the end of 25 minutes there was a very slight depressor response. From then on to 6.25 hours, there was a steady decline of pressure with

no pressor response on two releases of the stimulus. The secondary coil was then moved to 11 cm and when the weakened stimulus was temporarily released at 6.5 hours, the pressure almost doubled in height, showing improvement in the vasoconstrictor mechanism. Renewal of stimulation was followed by a fall to the previous level and then by a steady decline until death at seven hours. Red cells showed a progressive dilution from the control count

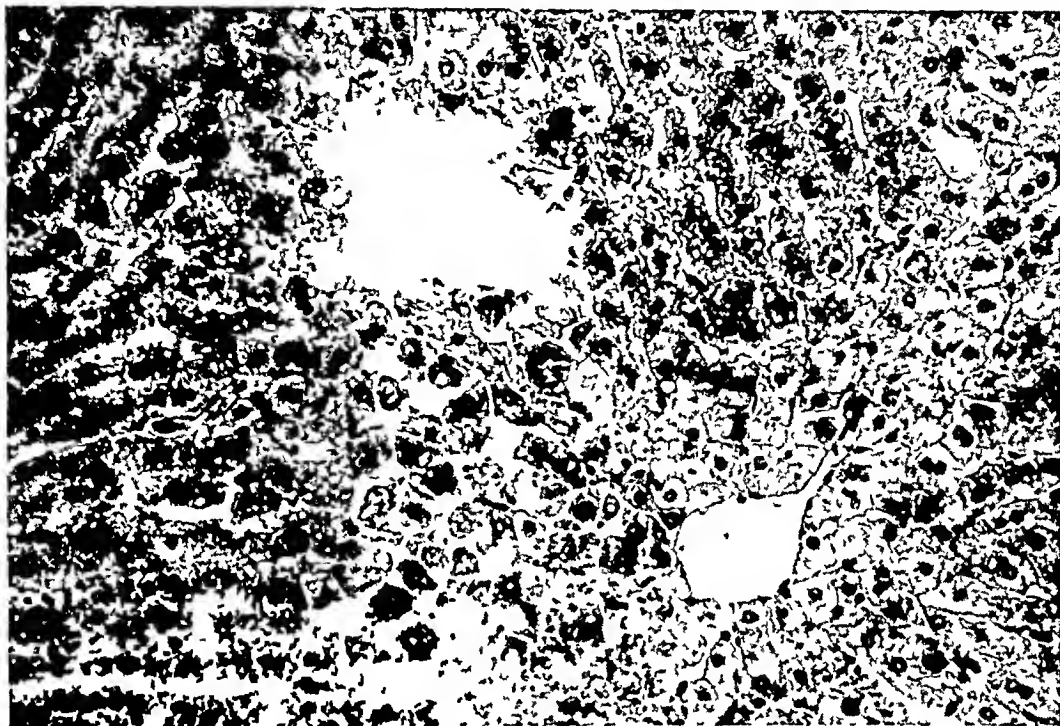


FIG. 6.—Rabbit 75. Focal necrosis of liver and lymph accumulation in necrotic area ($\times 300$)

of 7.04 to 6.24 at six hours, with terminal concentration to 6.70 on a sample taken 20 minutes before death.

Necropsy revealed gross congestion of the spleen and hypostatic congestion of the lungs. Microscopically, there was acute focal necrosis of the liver, protein precipitation in a few of the pulmonary alveoli and congestion of a dorsal section of lung. A section of jejunum showed marked lymphatic distention and lymphorrhhexis into the subserosal and submucosal spaces. There was no evidence of acute changes in sections of other tissues.

Two other experiments gave similar findings and are not reported in detail. Rabbit 27 lived for four hours and Rabbit 91 for seven hours and 30 minutes from the onset of stimulation. The bladders of all animals contained but a small quantity of urine, rarely more than ten cc. in all of the five experiments just reported, indicating suppression of secretion with the low blood pressure.

Figure 8, Rabbit 52, is a remarkable illustration of the relatively harmless effect of neurogenic lowering of the blood pressure in the upper range of what is arbitrarily designed as the shock level, *i.e.*, 70 mm Hg or below. On stimulation, the pressure dropped from 90 to between 50 and 60 mm Hg in

which vicinity it vacillated for five hours. The stimuli were relatively weak, eight to ten cm, and four releases during the period resulted in good pressor responses, the last one being somewhat reduced. At five hours the secondary coil was moved to seven cm, but the pressure slowly rose, reading 70 Mm at 6.5 hours. The coil was then moved to five cm and the stimulus maintained the pressure in the vicinity of 65 Mm Hg for the succeeding 2.75 hours. Because of a gradual rise of pressure, the coil was then moved to four cm. After a slight drop, which was sustained for 30 minutes, the stimulus was weakened by current leakage to the tissues and the pressure went up to 80 Mm within

Rabbit 54 Wt 4.2 Kg Urethane 2.1 Gm 1 p

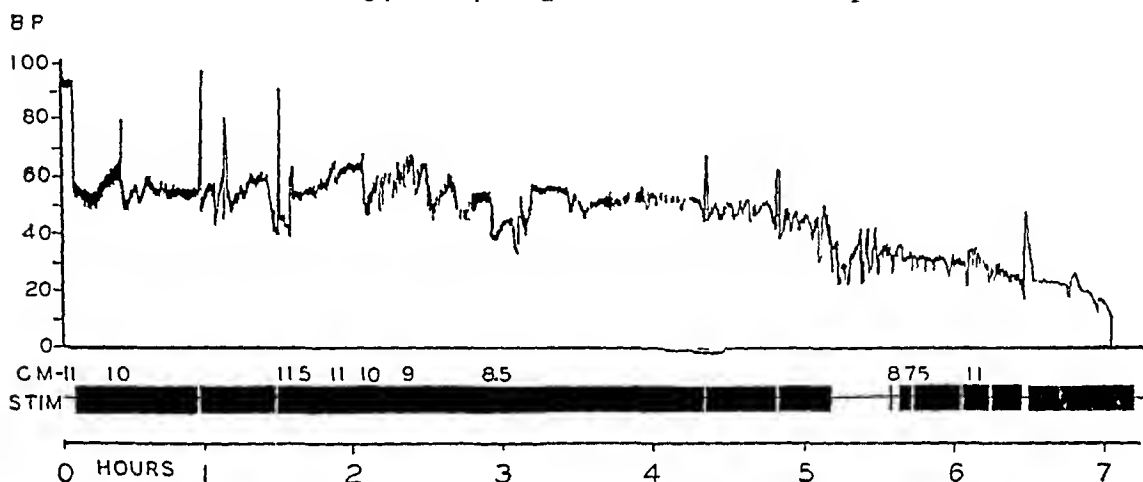


FIG 7—Prolonged vasodepression from aortic depressor nerve stimulation with progressive loss of vasoconstrictor tone and death. Weak stimulus in early period.

30 minutes. On release of the stimulus at 10.33 hours for six minutes, the pressure rose to the initial level. Renewed stimulation gradually lowered the pressure to 45 Mm Hg at 12 hours when another release resulted in a pressor response to 90 Mm Hg. The pressure then fluctuated and was at 50 Mm Hg 13 hours from the onset when death occurred suddenly, preceded by a momentary pressor response of 20 Mm on removal of the stimulus.

Eight red cell counts over the course of 11.75 hours showed a gradual decline to 5.12 from the control of 7.12. Hemoglobin and hematocrit readings had to be discarded because of faulty technic. Necropsy revealed gross evidence of congestion of spleen and kidneys and a light-colored liver. Microscopically, there was marked focal degeneration and necrosis of cell groups and scattered single cells in the liver. The lungs showed some dilated lymph channels and tiny hemorrhages. The kidneys had been eliminating red blood cells as indicated by their presence in the tubules of the papilla. Blood vessels were moderately congested. There was a little degeneration and sloughing of epithelium in the cortical tubules. The jejunum contained a few dilated lymph channels and there were many distorted nuclei and lymphocytes in the mucosa. Changes in other organs and tissues were insignificant.

The significance of the findings in this group of experiments is considered in the general discussion after the results of other relevant experiments have been given.

STIMULATION AND RELEASE

Figure 9, Rabbit 79, illustrates the ability of an animal to recover from the effects of prolonged lowering of blood pressure after removal of the stimulus either permanently or for a long period of time. During a four-hour period of stimulation, with a current that was progressively strengthened by moving the secondary coil from ten cm to five cm the blood pressure was maintained at levels fluctuating between 30 and 60 Mm, with an average pressure in the vicinity of 50 Mm. During this period the blood showed a fluctuating tendency to dilution and five brief releases of stimulus yielded

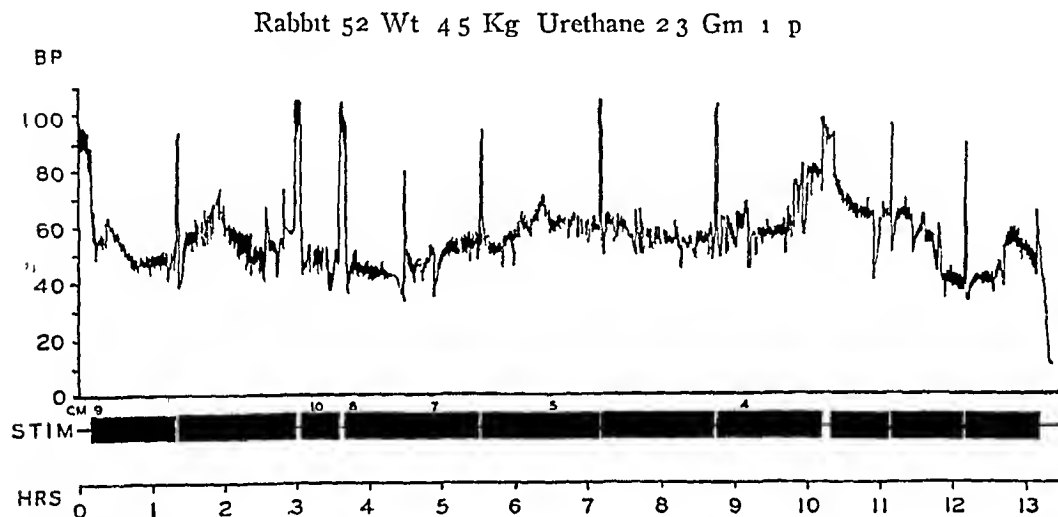


FIG 8—Long survival period with vasodepression to borderline shock levels from stimulation of the aortic depressor nerves with little impairment of vasoconstrictor tone to within one hour of death

well marked pressor responses. After 3.75 hours stimulation was discontinued, whereupon the blood pressure rose in less than a minute to the level before stimulation. It continued to remain in that vicinity for hours and was at 90 Mm Hg when the animal was killed seven hours after discontinuing stimulation. The blood was considerably diluted after two hours but was less so after 3.75 hours. Three and three-quarters hours after stopping the stimulus there was concentration slightly above that of the initial sample.

Animals which had long periods of vasodepressor and eventual weakening or exhaustion of the stimulus showed the same tendency to recovery and long survival.

The influence of blood and plasma on an animal whose circulation had been impaired by prolonged lowering of blood pressure by aortic depressor nerve stimulation was tested in seven rabbits, five by blood transfusion and two by plasma transfusion.

Figure 10, Rabbit 133, shows a condensed tracing of a severe vasodepression resulting from a relatively weak stimulus. The blood pressure declined promptly from 105 Mm Hg to 40 Mm, returning to the original level during a one-minute release period at the end of 30 minutes. Subsequently the pressure declined gradually to 22 Mm at the end of three hours.

and the animal appeared to be near death. The stimulus was then removed for five minutes, during which time the pressure responded very feebly, rising to 36 Mm Hg. Examination of blood samples (Table No III) taken before

TABLE III
RABBIT NO 133 (FIG 10)

Sample No	Time Hrs	R B C M	Hb Gm	Hcr %	CO ₂ Mm/L	O ₂ Mm/L	Plasma Proteins Gm %
1	Control	6 56	14 0	42 5	15 80	8 34	6 6
2	1 0	6 68	14 6	43 5	11 58	8 14	6 00
3	3 25	6 50	13 5	41 5	9 24	8 14	5 95
3 25 Transfused 72 cc Blood (20% of estimated blood volume)							
4	4 33	7 60	15 4	47 0	10 58	9 29	6 82
5	8 33	8 30	16 2	54 0			7 72
6	10 5	7 44	15 4	47 5			7 66

the onset of stimulation, one hour after and again 2 1 hours later, at the end of a five-minute period of release of the stimulus, revealed practically no changes in red cell counts, hemoglobin, hematocrit and oxygen, but a reduction of 9 per cent in plasma proteins and 31 per cent in carbon dioxide

Rabbit 79 Wt 57 Kg Urethane 285 Gm

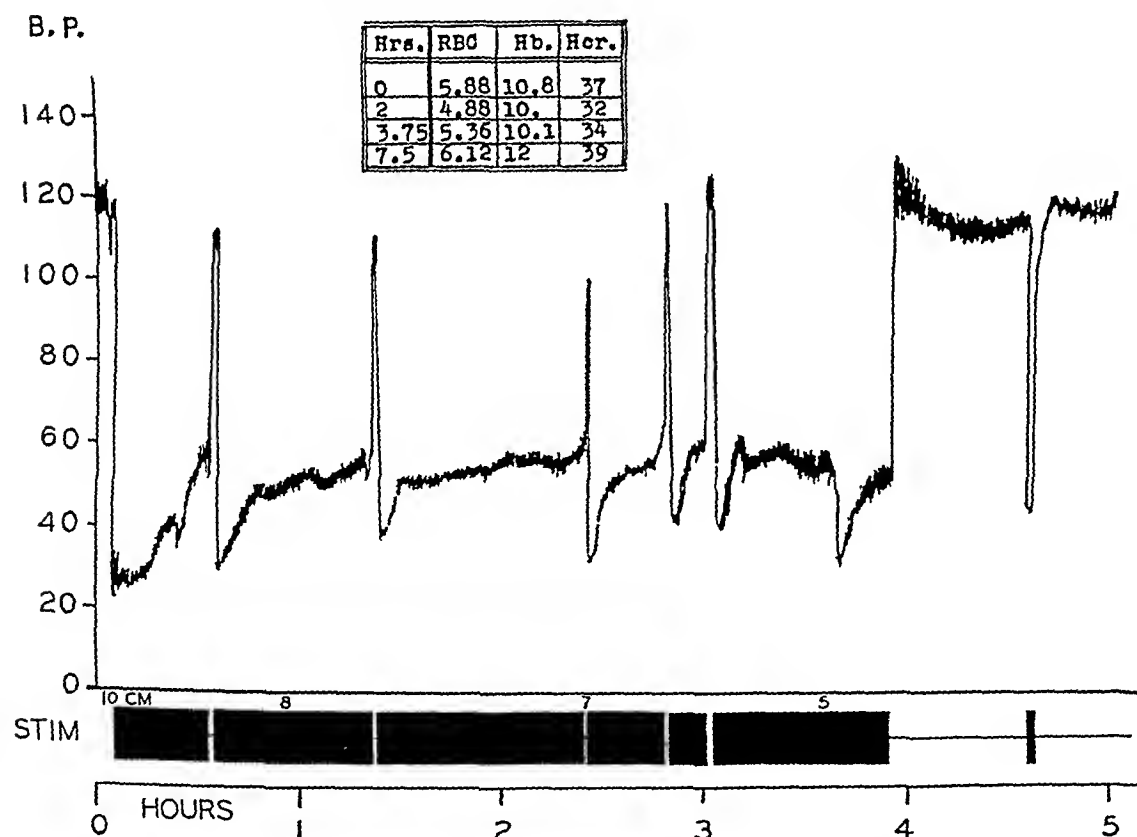


FIG 9—Vasodepression from prolonged aortic depressor nerve stimulation showing maintained vasoconstrictor tone and capacity of circulation to recover after release of stimulus

These relatively slight blood changes indicate that it was not oxygen deficiency but marked damage to the vasodepressor center, as shown by the feeble pressor response on release of stimulus that caused the severe embarrassment of the circulation

When the stimulus was reapplied, the blood pressure declined rapidly to 20 Mm Hg at which time a transfusion into the opposite femoral artery of 36 cc of heparinized rabbit's blood was given. The pressure rose during the transfusion and then started down, whereupon the stimulus was released and a second transfusion of the same amount was given. This produced a marked rise followed by a slight fall after which the pressure gradually improved and registered 70 Mm Hg 4.33 hours after the beginning of

Rabbit 133 Wt 5.34 Kg Urethane 2.67 Gm 1 p

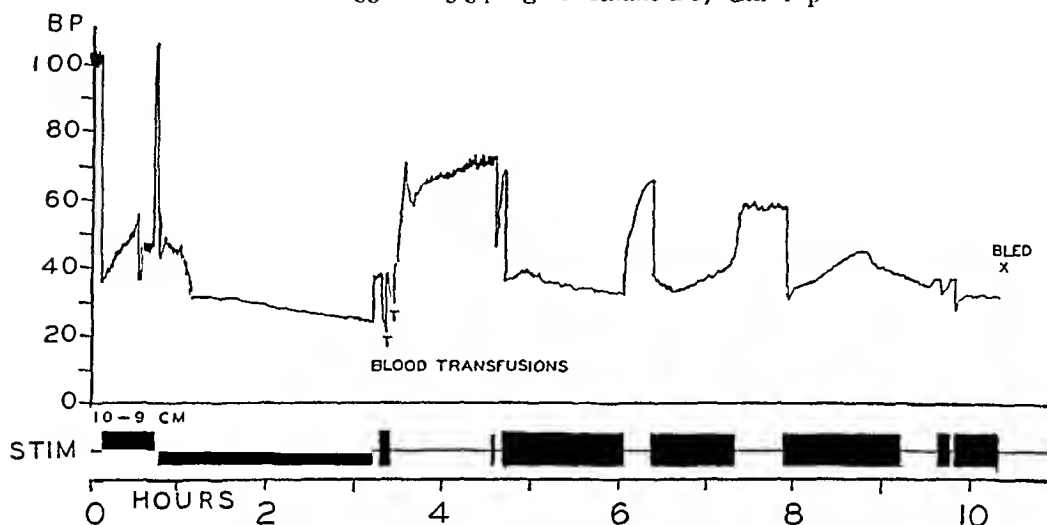


FIG 10.—Showing improved vasoconstrictor tone and prolonged life from blood transfusion given after a period of marked vasodepression and imminent death from aortic depressor nerve stimulation

stimulation. The blood was concentrated after the transfusion. The animal survived long periods of stimulation and vasodepression separated by shorter periods of release and elevation, until the pressor response was almost exhausted at 9.66 hours. There was also much blood lost from clotting and cannula washings causing terminal dilution. Bleeding of 48 cc at 10.5 hours caused death.

Figure 11, Rabbit 122, shows a condensed tracing of blood pressure held for 6.75 hours at an average level of about 40 Mm Hg by stimulation during which there were releases for periods varying from two minutes to ten minutes and totalling 33 minutes. The secondary coil was at ten cm for the first half-hour and at 0 cm thereafter. The rest periods, which were relatively long when compared with those in most of the experiments, helped to maintain the vasomotor center in good condition (as shown by the high pressor responses on stimulus release) and to prevent more than slight reduction in the blood elements analysed, as shown in Table IV. The pressure rose almost to the initial level on release of the stimulus at seven hours, the latter becoming ineffective because of leakage of current from fluid accumulation in the wound. At the end of an hour, with the restored pressure remaining constant, a 41 cc blood transfusion (15 per cent of the estimated blood volume) was given without producing a change in pressure level. After drying out the neck wound, the stimulus was reapplied at nine

hours and the pressure fell again to a low level. After 9.5 hours the animal was bled with the stimulus on and 122 cc or 45 per cent of the estimated volume of blood was obtained. Twenty-three and one-half cubic centimeters of blood had been removed in samples and cannula washings, making a total of blood loss of 145.5 cc. Despite the fact that the animal had been subjected to prolonged periods of low blood pressure, the circulation was so well preserved at the time the blood transfusion was given that no change in pressure was produced but the bleeding volume obtained subsequently under stimulation was undoubtedly greater than would have been the case without transfusion.

TABLE IV
RABBIT NO. 122 (FIG. 11)

Sample No	Time Hrs	R B C M	Hb Gm	Hcr %	CO ₂ Mm/L	O ₂ Mm/L	Plasma Proteins Gm %
1	0	6.18	11.8	36.5	23.00	6.81	6.63
2	0.25	5.58	10.9	33.0	20.59	6.31	5.93
3	2.75	5.80	11.5	34.0	14.79	6.58	5.24
4	4.25	5.40	11.1	32.0	12.75	6.42	5.88
5	6.8	5.40	11.1	32.0			

Fig. 12, Rabbit 124, shows a prolonged period of vasodepression from nerve stimulation with the secondary coil at 6 cm. During this period the circulating blood volume was determined, blood transfusions and adrenalin were given, periodic blood analyses were made and a terminal bleeding volume was obtained. In the course of the first four hours of stimulation with the blood pressure averaging 35 to 40 Mm Hg, there were variable reductions in the red cells, hemoglobin, hematocrit, plasma proteins, blood oxygen and carbon dioxide. Release of the stimulus for 15 minutes at 2.66 hours revealed a moderate reduction in the pressor response but the response was somewhat greater at four hours, probably due to the slightly elevated pressure during the preceding 45 minutes. Forty-five cubic centimeters of blood was transfused at 4.75 hours and 30 cc at five hours, making a total of 21 per cent of the estimated blood volume. Release of the stimulus after the first transfusion showed additional improvement in the pressor responses. Four minims of 1/15,000 adrenalin solution then produced a marked elevation in pressure which fell to the previous level in three minutes. The blood pressure gradually crept up to 60 Mm at six hours. Release then produced a marked pressure rise but the response to stimulation became irregular and after 7.4 hours was exhausted, at which time the stimulus was removed and the pressure leveled at 120 Mm Hg. After eight hours the animal was sacrificed by bleeding 195 cc, or 55 per cent of the estimated blood volume. All of the organs were pale and, microscopically, the liver and kidney showed scattered areas of acute parenchymatous degeneration. This is another example of a very marked vasodepression which was well tolerated for four hours and of improvement of the circulation during effective stimulation by the transfusion of blood.

The blood volume determination was one of a series of five made by Dr Paul W Schafer on rabbits during vasodepression to a shock level which had been maintained for two to three hours before beginning the test (Table V) A control sample was drawn, dye was injected and four successive four cc samples were drawn at ten-minute intervals A transfusion equal to the total amount of blood withdrawn was given at the end

Figure 13, Rabbit 139, shows the blood pressure during aortic-depressor nerve stimulation held at a fluctuating but remarkably low level, averaging less than 30 Mm Hg for four hours, except for the five release periods, totaling

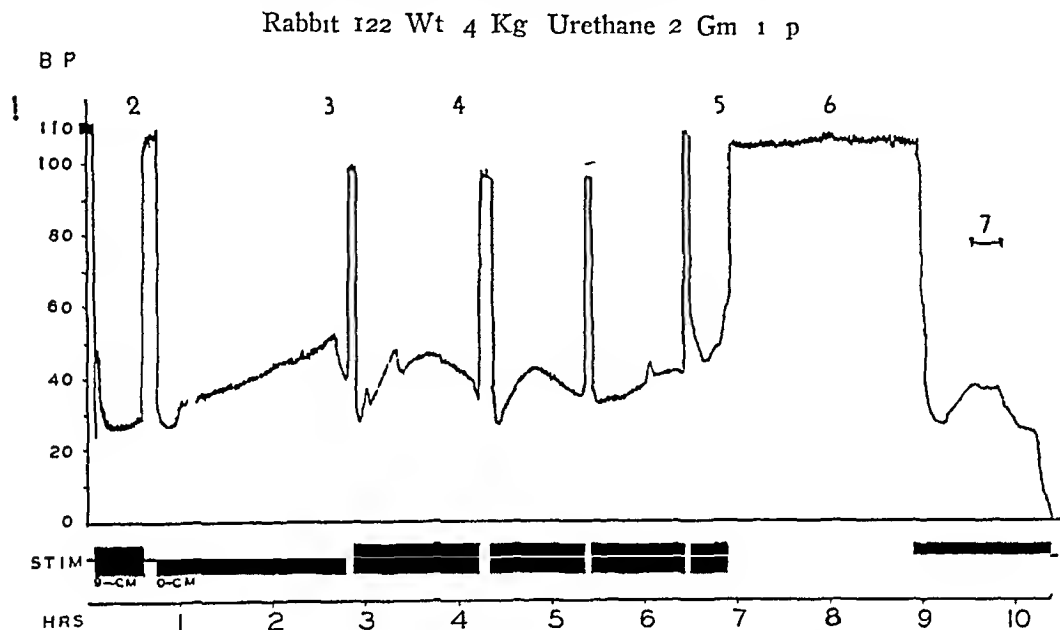


FIG 11—Seven hour period of vasodepression from depressor nerve stimulation, with preservation of vasoconstrictor tone throughout and recovery of blood pressure to normal level during prolonged release of stimulus Transfusion (6) did not elevate pressure but increased the terminal bleeding volume (7) Blood samples (1) to (5)

ten minutes The stimulus was started with the secondary coil at ten cm, which was moved to eight cm at three hours Release of the stimulus just after one hour and at 2 6 hours showed good pressor responses, but three releases between 2 9 and 3 6 hours showed reductions to the vicinity of two-thirds the original level The blood constituents determined during this four-hour period showed a gradual decrease with the exception of the red blood cells, hemoglobin and hematocrit of the third sample at 2 25 hours Both the vasomotor center and the composition of the blood were remarkably well preserved considering the low level of blood pressure during the period

A plasma transfusion was then given in the opposite femoral artery during which time the pressure recording was stopped With resumption of the recording, the pressure was found elevated but it quickly returned to the vicinity of the previous level Release of the stimulus for seven minutes after a 30-minute interval resulted in an elevation of pressure to 100 Mm Hg with a prompt return to a low level on restimulation A second transfusion of the same amount produced marked elevation of blood pressure which

Rabbit 124 Wt 5.23 Kg Urethane 2.6 Gm 1 p

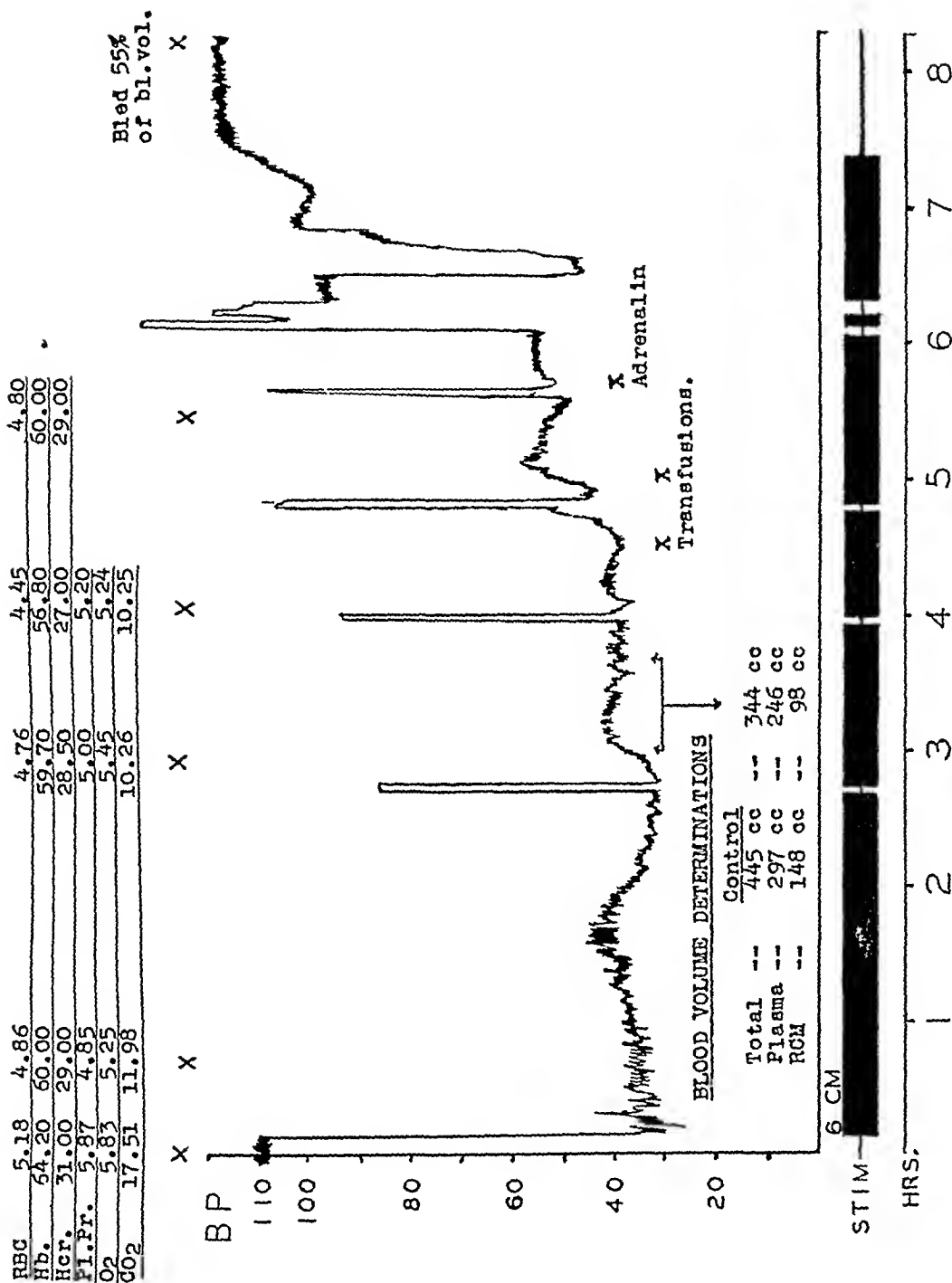


Fig. 1.—Marked lowering of blood pressure well tolerated for four hours. Blood volume estimated toward end of that period moderately reduced. Blood pressure and release responses improved following blood transfusions.

declined to the previous level in 10 minutes. At 56 hours, with the stimulus on, the animal was bled 108 cc, or 40 per cent of the estimated blood volume. This lowered the blood pressure to 20 Mm Hg. On release of the stimulus the blood pressure promptly rose to 60 Mm showing marked activity of the vasomotor center after severe blood loss. With the pressure again at 20 Mm from renewal of stimulation, an additional 28 cc, or 10 per cent of the estimated blood volume, was removed before death occurred. Blood analyses after the first and second transfusions at 45 and 53 hours, respectively, revealed a dilution of the cellular elements, an increase in the plasma proteins, no change in blood carbon dioxide, and first a decline and then a rise in blood oxygen. After the first bleeding there was a further reduction of red cells, hemoglobin and hematocrit.

TABLE V

CIRCULATING BLOOD VOLUME DETERMINATIONS BY THE EVANS BLUE DYE METHOD ON RABBITS IN WHICH THE BLOOD PRESSURE WAS MAINTAINED AT SHOCK LEVEL BY AORTIC DEPRESSOR NERVE STIMULATION

	Rabbit No 102	Rabbit No 119	Rabbit No 124	Rabbit No 127	Rabbit No 130	Average Decrease
Weight	5.1 Kg	6.0 Kg	5.2 Kg	4.7 Kg	5.0 Kg	
Elapsed time from start of stimulus	2.5 hrs	2.5 hrs	3.0 hrs	2.0 hrs	2.25 hrs	
Control total volume	320 cc	350 cc	445 cc	290 cc	254 cc	
Total vol during stim	304 cc	275 cc	344 cc	248 cc	204 cc	
Decrease	16 cc	75 cc	101 cc	42 cc	50 cc	
% Decrease	5%	21%	23%	15%	20%	17%
Control plasma volume	203 cc	200 cc	297 cc	185 cc	168 cc	
Plasma vol during stim	214 cc	175 cc	246 cc	173 cc	161 cc	
Decrease	(Inc) 11 cc	25 cc	51 cc	12 cc	7 cc	
% Decrease	(Inc) 6%	13%	17%	7%	4%	7%
Control red cell mass	117 cc	150 cc	148 cc	105 cc	86 cc	
Red cell mass during stim	90 cc	100 cc	98 cc	75 cc	43 cc	
Decrease	27 cc	50 cc	50 cc	30 cc	43 cc	
% Decrease	23%	33%	34%	29%	50%	34%

The plasma transfusions, while diluting the cellular elements, increased the plasma proteins which had been considerably reduced during the previous period of low blood pressure. The blood oxygen and carbon dioxide were relatively little changed and the vasomotor center was apparently strengthened, as judged by the excellence of the pressure responses on release of the stimulus after the first transfusion and after the first bleeding, which was massive.

In a second experiment, where stimulation maintained the pressure between 40 and 50 Mm Hg for 27 hours and the pressor response on release of the stimulus was to the prestimulation level, the giving of 23 cc of plasma, or 85 per cent of the estimated blood volume, was followed by an increase of 15 Mm in the height of the response on release of stimulus after 15 minutes. A second similar transfusion after an additional 14 hours of vasodepression was followed by a slightly higher pressor response. Bleeding to death then yielded 63 per cent of the animal's estimated blood volume.

Rabbit 139 Wt 4 Kg Urethane 2 Gm 1 p

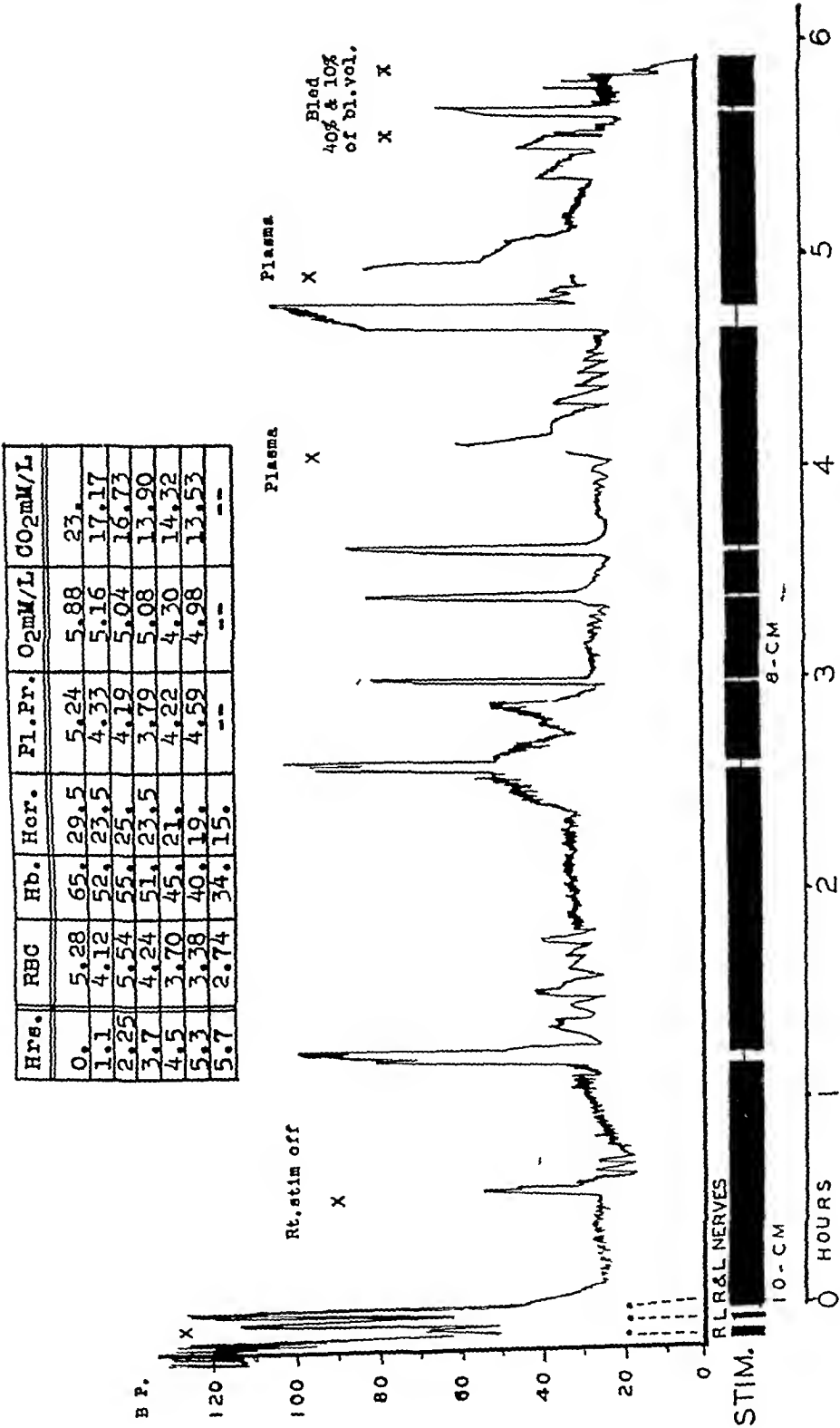


Fig 13.—Very low blood pressure from nerve stimulation with only moderate blood dilution and reduction of vasopressor response on periodic release during first four hours Plasma transfusions beneficial

The results of these experiments warrant the conclusion that when the circulation has been impaired from lowering the blood pressure by the action of vasodepressor nerve impulses, blood or plasma transfusion is beneficial

HEMORRHAGE AND DEPRESSOR NERVE STIMULATION

In case of accidental wounds in man both hemorrhage and vasodepression from afferent nerve impulses as produced by psychic influences may be active in the lowering of blood pressure and the question arises as to the rôle which each may play in the production of shock. They may occur simultaneously or either one may precede the other. Thus there may be an immediate and marked fall of blood pressure produced by fainting and a subsequent fall of pressure produced by hemorrhage, or *vice versa*.

In testing the relative importance of vasodepressor nerve impulses and hemorrhage in the production of shock, the blood pressure in one group was first lowered by aortic-depressor nerve stimulation and then the rabbits were bled. In a second group the animals were first bled to shock levels and then the aortic-depressor nerves stimulated.

TABLE VI

EXTENT TO WHICH ANIMALS WITHSTAND INTERMITTENT BLEEDING AND CONTINUOUS STIMULATION
AFTER VARYING PERIODS OF LOW BLOOD PRESSURE PRODUCED BY AORTIC-DEPRESSOR NERVE STIMULATION

Exp No	Wt Kg	Initial Pressure Mm Hg	Stimulus Strength	Pressure During Stimulation	Duration of Stimulus		Intermittent Bleeding Time Hrs	% Blood Volume Lost		
					Total Hrs	Before Bleeding Hrs		From Bleeding	Samples, Clot Wash and Surgery	Total
97	3 9	115	9-8 cm	50-60	1 9	1 0	0 9	45	2	47
84	5 4	110	11-8 cm	30-60	2 7	1 2	1 5	27	7	34
99	4 0	110	10-9½ cm	38-46	2 0	1 3	0 7	51	7	58
80	4 9	105	11-9 cm	20-60	3 2	2 2	1 0	35	9	44
88	4 1	120	10-1 cm	50-70	3 5	2 5	1 0	26	10	36
82	4 9	110	8-6 cm	30-60	6 7	4 5	2 2	36	14	50
Averages						2 2	1 2	36 7%	8 1%	44 8

The effect of hemorrhage superimposed on a period of low blood pressure produced by aortic-depressor nerve stimulation was studied in 11 rabbits, six by intermittent bleeding and five by continuous bleeding. Table VI shows that intermittent bleeding after 1- to 4.5-hour periods of vasodepression to definite but not to extreme shock levels was well tolerated, as judged by the amounts it was necessary to bleed for the production of death. They ranged from 36 to 58 per cent of the estimated blood volume and averaged in the vicinity of normal.

Figure 14, Rabbit 82, shows the result in the case of the longest period of vasodepression before intermittent bleeding. The blood pressure averaged about 40 Mm Hg during the first 4.33 hours, with a gradual rise in the last hour. Table VII reveals a well marked blood dilution and reduction in oxygen and carbon dioxide. The pressor responses during brief releases of the stimulus were well preserved. The animal was bled 62 cc at 4.33

hours (A), 30 cc at 5 25 hours (B), 19 cc at 6 16 hours (C) and 5 cc to death at 6 5 hours (D)—a total of 116 cc, equal to 36 1 per cent of the estimated blood volume. Including cannula washings and samples, a total of 162 cc, or 50 5 per cent of the estimated blood volume, was lost. Samples of bloods (B) and (C) showed a progressive dilution. Four pressor responses on release of stimulus during the bleeding period showed only moderate reduction but a fifth release just before death gave no response.

TABLE VII
RABBIT NO 82 (FIG 14)

Time Hrs	R B C M	Hb Gm	Hcr %	CO ₂ Mm/L	O ₂ Mm/L
Control	5 66	12 0	36 0	18 98	6 98
1 0	1 86	10 5	33 0	15 99	6 32
2 0	4 84	10 5	32 5		
3 0	4 32	10 1	31 5	13 32	6 41
4 0	1 24	9 3	30 0	8 36*	3 63*
4 33	Bled 62 cc (19 3% of estimated blood volume)				
5 25	3 38	7 3	21 0	9 11	4 07
5 25	Bled 30 cc (9 3% of estimated blood volume)				
6 16	2 90	6 6	19 0	6 16	3 85
6 16	Bled 24 cc (7 5%) to death				

*Micro sample used

Rabbit 82 Wt 4 75 Kg Urethane 2 38 Gm 1 p

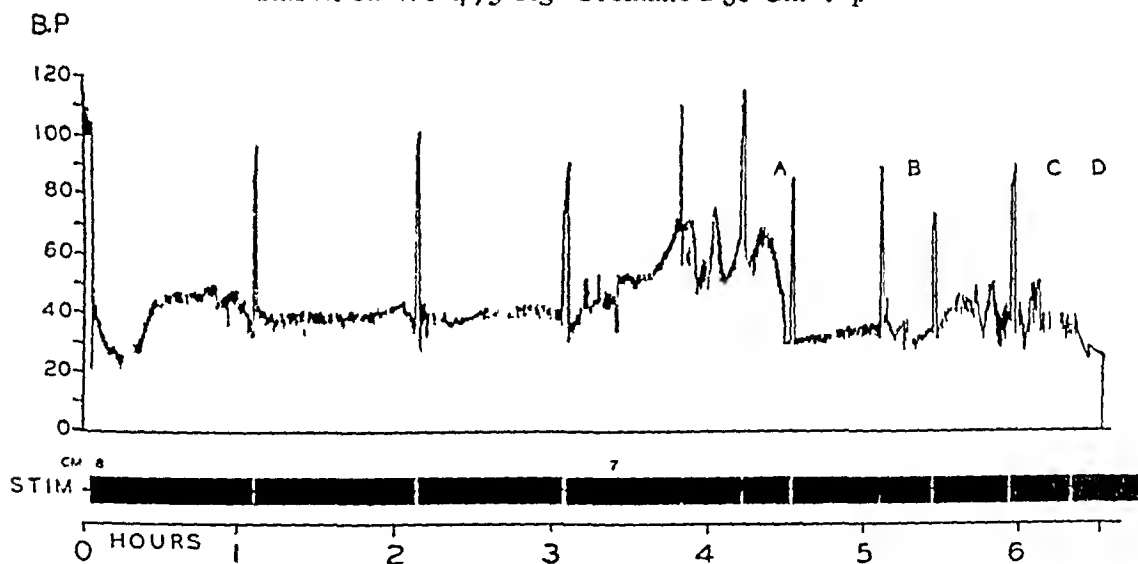


FIG 14—Vasodepression from aortic depressor nerve stimulation with intermittent terminal bleeding well tolerated. Bled A—62 cc (19 3%), B—30 cc (9 3%), C—19 cc (5 9%), D—5 cc (1 6%), total 116 cc (36 1% of estimated blood volume). Cannula wash and surgery 34 cc (10 6%), samples—12 cc (3 6%), total blood loss 162 cc (50 5%).

This experiment shows the remarkable ability of an animal, which for 4 33 hours had had a low blood pressure with progressive hemodilution and oxygen and carbon dioxide reduction as a result of stimulation of the aortic-depressor nerves, to tolerate superimposed intermittent bleeding during an additional 2 16-hour period of continuous stimulation.

In the experiments represented in Table VIII, the animals were sacrificed by continuous bleeding after similar periods of low blood pressure from aortic-depressor nerve stimulation. In the first three experiments, the bleed-

ing was carried out with the stimulus still in operation. The behaviour under stimulation before bleeding was, in general, similar to that in the previous experiments, but when the animals were sacrificed by continuous bleeding, the volume obtained was appreciably less than that from controls and from those bled intermittently over a much longer period.

Figure 15, Rabbit 90, shows the blood pressure averaging about 55 Mm Hg during a 4 3-hour period of stimulation throughout which there was a progressive hemodilution (Table IX) and weakening of the pressor response

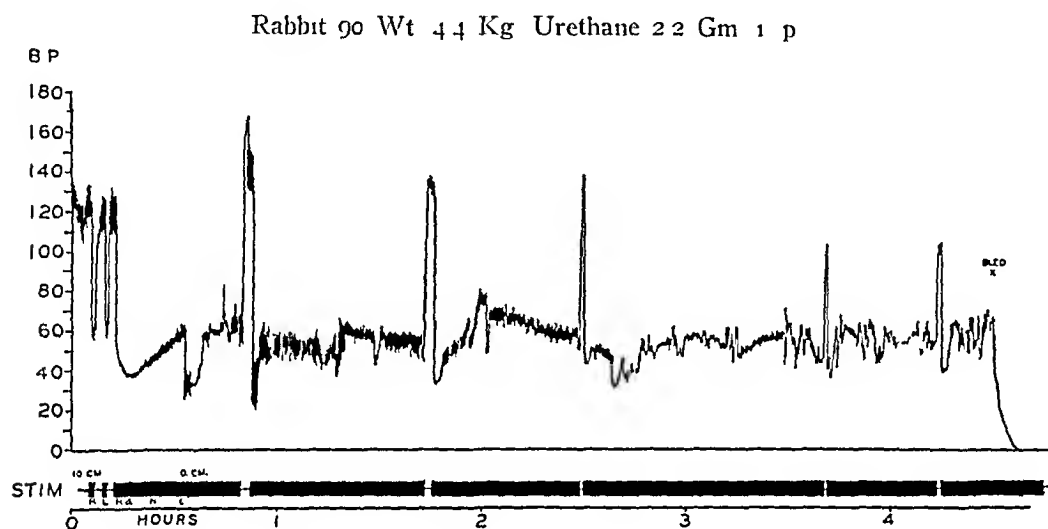


FIG 15—Vasodepression from aortic depressor nerve stimulation with gradually decreasing vaso motor tone and terminal bleeding to death. Bleeding volume moderately reduced. Terminal bleeding 91 cc (31%), cannula washings and surgery 12 cc (4%), samples 12 cc (4%), total blood loss 117 cc, or 39% of the estimated blood volume.

on release of the stimulus. The blood carbon dioxide was reduced and the oxygen was increased, this being the only experiment in which O_2 increase occurred. It might have been related in part to the rapid respirations which averaged 90 per minute after the first hour. The animal was bled 93 cc to death, and lost 12 cc in samples and 12 cc in cannula wash—a total of 117 cc, or 39 per cent of the estimated blood volume. The reduction in bleeding volume would indicate that the previous period of vasodepression had somewhat impaired the ability of the animal to tolerate blood loss.

Figure 16, Rabbit 110, shows the blood pressure averaging 40 to 45 Mm Hg for four hours (aside from two release periods) with a moderate hemodilution and only a slight reduction in pressor response during a seven-minute release of stimulus 30 minutes before the end. With stimulation continued, it required 20 minutes for bleeding 110 cc to death. This amount, plus 13 cc lost otherwise, gave a bleeding volume of 35 per cent, based on the calculated blood volume determined 24 hours before the experiment. The blood volume calculated after 2 75 hours showed a reduction of 21.4 per cent total volume, 12.5 per cent plasma volume and 33.33 per cent red cell mass. The hemodilution and reduction of circulating blood volume were responsible for the reduced bleeding volume.

In the last two experiments of Table VIII the stimulus was removed and a rest period allowed before bleeding to death

Rabbit 102, weight 5.1 Kg, with an initial blood pressure of 100 Mm Hg, had a prompt fall to 24 Mm on stimulation of the left aortic-depressor nerve and the pressure ranged between 24 and 50 Mm for three hours, averaging about 40 Mm. During the first half-hour there was occasional struggling, after which the animal became unresponsive. Blood dilution resulted as follows: red blood cells from 5.74 to 4.76, hematocrit 35 to 27.5, plasma proteins 6.25 to 4.94 Gm per cent, blood oxygen 6.43 to 6.12, and carbon dioxide 21.94

TABLE VIII

EFFECT OF BLOOD LOSS FROM CONTINUOUS BLEEDING NECESSARY TO CAUSE DEATH AFTER PERIODS OF LOW BLOOD PRESSURE FROM AORTIC-DEPRESSOR NERVE STIMULATION

						% of Blood Volume Lost		
Exp No	Wt Kg	Initial Pressure Mm Hg	Strength of Stimulus	Total Time Stimulated Hrs	Pressure During Stimulation Mm Hg	Surgery, Clot		
						From Bleeding	Wash and Samples	Total
With Stimulation On								
81	4.5	100	10-9 cm	1.0	28-40	35.0	4.0	39
119	6.0	100	8 cm	4.0	30-50	31.4	3.6	35
90	4.4	120	0 cm	1.3	40-60	31.0	8.0	39
						32.5 Avg	5.2 Avg	37.7 Avg
With Stimulation Off								
102	5.1	100	10-9 cm	1.0	24-40 for 3 hrs (3 hrs rest followed) 26-30 for 5 hrs (2.5 hrs rest followed)	36	10	46
117	4.0	115	10-7 cm	2.2	30-60 for 1.7 hrs (0.5 hr rest followed)	42	4	46
						39% Avg	7% Avg	46 Avg

to 20.05. A blood volume determined during the last hour was almost the same as the control. (See Table V). The pressor responses on brief release of stimulus were only slightly reduced. Release of the stimulus at the end of three hours was followed by a rapid rise of the pressure to 110 Mm Hg, where it continued and there was soon a resumption of struggling. Beginning three hours later the blood pressure was held at an average level of 30 Mm Hg for 35 minutes by stimulation, during which time the animal again became quiet. After removal of the stimulus, the blood pressure promptly rose again and continued at an average level of 115 Mm. The animal again struggled and at the end of 1.5 hours was awake and cried when his wounds were disturbed. Vasodepression increased the degree of anesthesia and analgesia. An hour later, the animal was bled 120 cc to death. The total blood loss during the experiment was 156 cc, or 46 per cent of the estimated blood volume, indicating little damage done to the circulation by the stimulation.

Rabbit 117, weight 4.0 Kg, on stimulation had a drop of blood pressure from 115 Mm to 32 Mm Hg. It gradually ascended during 2.2 hours to 60 Mm Hg when the stimulus was removed. There was no significant blood change. On release of stimulus, the pressure quickly rose to 120 Mm Hg where

Rabbit 119 Wt 5.95 Kg Urethane 3 Gm 1 p

REG	Hb.	Hcr.	CO ₂	O ₂	Plasma
gms	%	Mm/L	Mm/L	Mm/L	Proteins
gms	%	Mm/L	Mm/L	Mm/L	gms. %
1 5.86	13.04	39.0	16.71	7.75	5.97
2 5.77	12.42	36.0	15.76	7.17	5.15
3 5.58	11.82	34.5	13.84	7.06	5.18

p 200 p 180
r 48 r 48

p 220
r 64

p 200 p 160
r 48 r 48

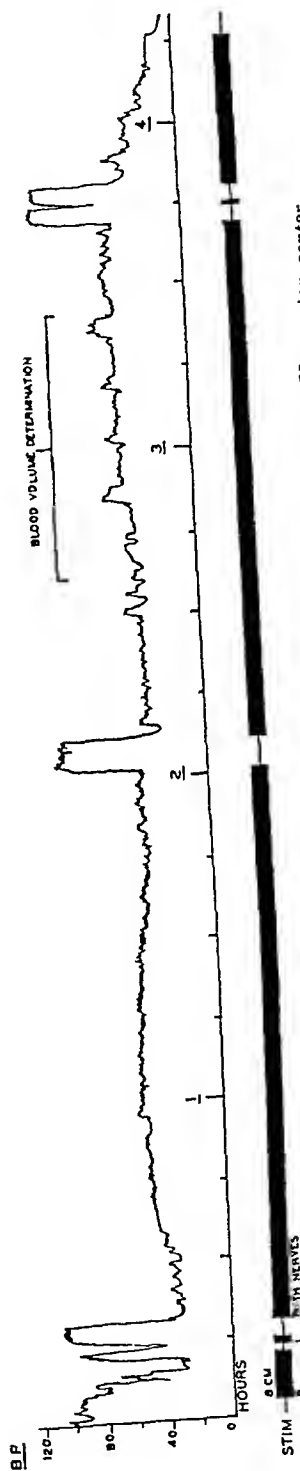


Fig 16—Vasodepression by aortic depressor nerve stimulation for four hours. Vasomotor center little impaired. Bleeding volume moderately reduced (35 per cent) by hemodilution and reduced circulating blood volume.

it remained for one-half hour. The animal was then sacrificed by bleeding 115 cc. Eleven cubic centimeters of blood were lost during the experiment, giving a total of 126 cc, or 46 per cent of the estimated blood volume.

These experiments demonstrate that, in the rabbit, hemorrhage superimposed on a low blood pressure maintained for periods varying from one to four hours by vasodepressor nerve stimulation is relatively well tolerated. If the bleeding is continuous, the animal is killed by loss of a smaller amount of blood than if the bleeding is intermittent. In the latter case, and in case the stimulus is released and a rest period elapses before bleeding, the bleeding volume may be but little or no less than that of anesthetized animals bled without stimulation.

TABLE IX
RABBIT NO. 90 (FIG. 15)

Time Hrs	R B C M	Hb Gm	Hcr %	CO ₂ Mm/L	O ₂ Mm/L
Control	8.10	16.2	39.8	20.02	5.86
1.0	6.26	13.4	35.3	10.27	6.14
3.0	5.98	13.3	34.0	14.15	6.90
4.0	5.91	13.3	33.0	13.10	7.01

Bled 93 cc (31%) to death

HEMORRHAGE TO SHOCK LEVELS FOLLOWED BY AORTIC-DEPRESSOR NERVE STIMULATION

In case of injury in man, there may be blood loss that is sufficient to lower the blood pressure to shock levels and then vasodepressor impulses, created by the psychological reaction to the distressing surroundings, may bring on syncope. A gunshot wound of the abdomen may injure blood vessels, resulting in shock from hemorrhage, and the surgeon during operation may produce an additional decline in pressure by intra-abdominal manipulation which sets up afferent depressor impulses. The effects in such clinical cases may be approximated experimentally by producing shock from hemorrhage and then superimposing a further fall of blood pressure by aortic-depressor nerve stimulation.

In six rabbits the nerves were prepared for stimulation and the animals then bled intermittently in varying amounts from 15 to 35 per cent of the estimated blood volume and to various shock levels of blood pressure ranging from 40 to 70 Mm Hg. Nerve stimulation 15 to 45 minutes after the last bleeding produced an additional fall of blood pressure averaging 24 Mm Hg (Table X). While the effects of the vasodepression from stimulation were not uniform, it usually appeared to shorten somewhat the period of survival as compared with controls (Table XI).

Figure 17, Rabbit 101, shows the effect of five bleedings at 15-minute intervals of 30 cc, 15 cc, eight cc and seven cc, respectively, making a total of 91 cc, or 30 per cent of the estimated blood volume. Fifteen minutes after the last bleeding the blood pressure was slightly on the rise at 54 Mm Hg. Stimulation beginning then lowered the pressure to 26 Mm, from which

level it gradually rose and then declined to death in one hour. Release of the stimulus at 24 minutes resulted in elevation of pressure to 70 Mm Hg, which is an indication that the stimulation had so far done little harm, but a second release at 36 minutes showed a much smaller pressor response, which spoke for damage to the vasomotor center. The blood diluted markedly during the bleeding period but only slightly during stimulation (Table XII). Judging by the rapid change in vasomotor tone, the stimulation appeared to hasten death to some extent.

TABLE X

RABBITS BLED INTERMITTENTLY TO SHOCK LEVEL WHICH WAS FOLLOWED BY FURTHER VASODEPRESSION FROM STIMULATION OF THE AORTIC-DEPRESSOR NERVES

Exp No	Wt Kg	Initial Pressure Mm Hg	Time Required to Bleed	Total Amount Bled	Pressure Levelled		Range of Pressure Levels During Stimulation	Survival Time After Stimulus Applied	Total Blood Loss Incl Samples and Clot Wash
					Within Min	At Mm 11g			
111	4.4	104	0.25 hr	15.0%	30	70	46 to 68	2.0 hrs	20.0%
107	4.7	110	0.25 hr	17.5%	45	50	28 to 34	1.0 hr	20.0%
101	4.5	120	1.0 hr	30.0%	15	54	28 to 44	1.0 hr	34.6%
92	5.1	100	0.25 hr	20.0%	45	40	20 to 22	1.1 hrs	25.5%
100	4.9	120	1.0 hr	35.0%	20	50	26 to 30	0.4 hrs	40.0%
Averages				23.8%				1.1 hrs	28.0%
118	6.0	100	0.25 hr	15.0%	30	60	16 to 34	7.5 hrs	26.0%

TABLE XI

CONTROL INTERMITTENT BLEEDINGS TO SHOCK LEVEL

Exp No	Wt Kg	Initial Pressure Mm Hg	Bleeding to Shock Level		Survival After Bleeding Hrs	Total Blood Loss Incl Samples and Clot Wash
			Time	%		
120	4.0	96	0.5 hr	20.0	1.8	20.0%
104	4.8	96	1.25 hrs	25.0	1.5	34.0%
142	3.8	100	2.16 hrs	30.0	1.5	30.0%
95	4.4	120	2.0 hrs	33.0	0.5	40.0%
103	5.7	110	1.75 hrs	37.5	3.1	44.0%
105	5.0	126	1.75 hrs	40.0	0.8	44.0%
Group averages				30.9%	1.5	35.3%

TABLE XII

RABBIT NO. 101 (FIG. 17)

Time Hrs	R B C M	Hb Gm	Hct %	CO ₂ Mm/L	O ₂ Mm/L
Control	4.92	11.3	34.6	17.90	6.76
0.33		Bled 91 cc (30% of blood volume)			
1.33	3.72	8.8	25.0	7.95	5.14
1.66		Stimulus applied			
2.16	3.52	8.5	23.6		
2.5	3.37	7.9	23.0	4.64	4.60

However, Figure 18, Rabbit 118, illustrates the necessity of being cautious about concluding that vasodepression from nerve stimulation superimposed on low blood pressure from hemorrhage necessarily shortens the period of survival under stimulation. After bleeding 34 cc and 15 minutes later, 17 cc, a total of 15 per cent of the estimated blood volume, the blood pressure leveled at 60 Mm Hg one-half hour later. Stimulation was then begun and the blood pressure fell to 16 Mm Hg. It slowly rose during the next 55

hours to 34 Mm and then more rapidly declined until death at the end of two hours. Necropsy revealed gross evidence of congestion of spleen, liver and kidneys. Microscopically, the sinuses of the spleen were markedly congested (Figure 19). The kidney showed moderate congestion and necrosis of tubules (Figure 20). There was mild hepatic congestion and scattered necrosis of liver cells singly and in groups. The lungs contained little blood but there was protein precipitate in some of the alveoli. The adrenals, heart and skeletal muscle showed no changes.

Rabbit 101 Wt 4.53 Kg Urethane 2.25 Gm

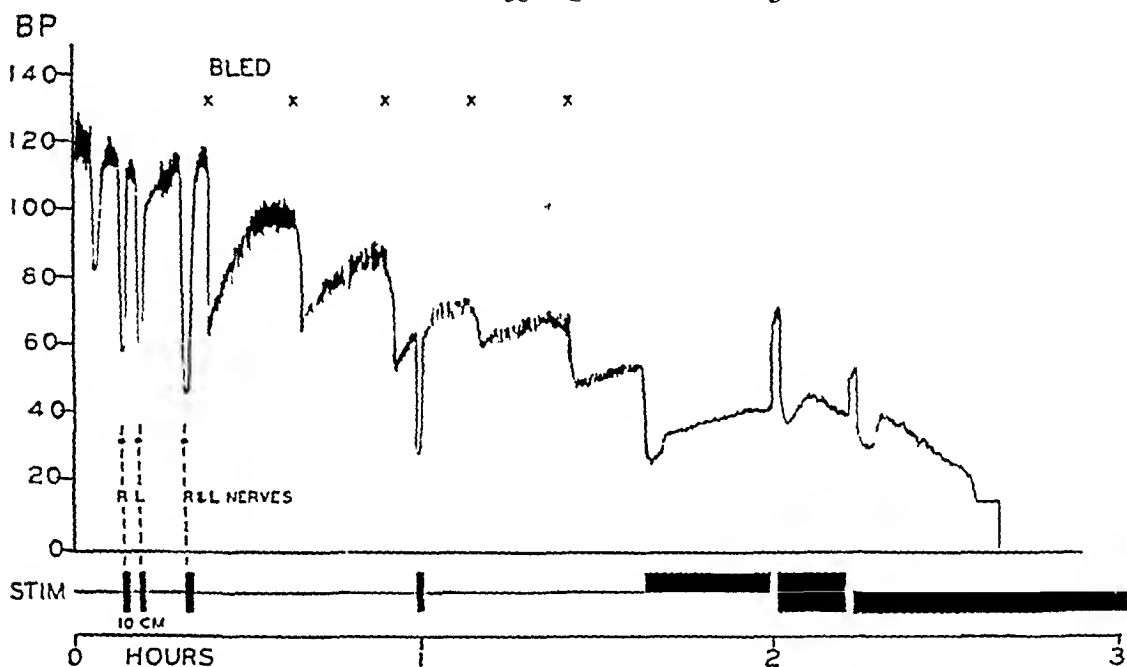


FIG 17—Intermittent bleeding to shock level followed by further vasodepression from aortic depressor nerve stimulation which apparently shortened the time of impairment of vasomotor tone and shortened the survival period.

This 7.5-hour period of survival during nerve stimulation was longer than that of any of the entire series in which stimulation was not preceded by bleeding and in which the pressure was held at a similarly low level. In addition, 36 cc of blood was lost from surgery, cannula washings and samples. The low blood pressure was due partly to the hemorrhage and partly to the stimulation but the vasomotor response on release held up remarkably well, considering the low level of pressure during the first half of the period of stimulation. Blood examination showed sharp hemodilution following the hemorrhages and moderate dilution during the period of stimulation (Table XIII).

An effect of marked lowering of blood pressure by aortic-depressor nerve stimulation observed incidentally was a tendency to deepening of the degree of anesthesia and analgesia as the period of vasodepression was prolonged. When the blood pressure was maintained at a low level continuously, the anesthesia and analgesia were observed to deepen gradually. When the stimulus was then removed, there was a gradual lessening in degree of both

This is illustrated in Rabbit 102, and well shown in Figure 21, Rabbit 140,

Stimulation of the saphenous nerve in the latter animal produced a transitory fall and rise of blood pressure with a struggle and faint cry. The aortic-depressor nerve was then stimulated and the pressure fell sharply, to range between 26 and 42 Mm Hg during a one-hour and five-minute period. Stimulation of saphenous nerve five minutes after the onset of vasodepression produced a struggle and faint cry but 40 and 52 minutes later it produced no response. Eight minutes after release of the depressor stimulus there was still no response to saphenous nerve stimulation, but 12 minutes later there was a mild struggle on stimulation. Cutting of the sciatic nerve then

TABLE XIII
RABBIT NO 118 (FIG 18)

Time Hrs	R B C M	Hb Gm	Hcr %	CO ₂ Mm/L	O ₂ Mm/L	Plasma Proteins
0	6 32	12 0	36 8	15 34	7 08	6 37
1 5	6 00	11 7	36 0	12 40	7 01	5 82
1 5		Bled 34 cc (10% of estimated blood volume)				
1 75	5 62	10 8	32 5	12 14	6 54	5 51
1 75		Bled 17 cc (5% of estimated blood volume)				
2 16		Stimulus applied				
4 16	4 96	9 53	28 7	7 87	5 68	4 88
7 16	4 90	9 45	28 7			
9 5	4 78	9 20	27 9			

produced a struggle, as did stimulation of it five minutes later. A second period of 1 25 hours of vasodepression was then produced. Fifteen minutes after the onset, sciatic nerve stimulation produced a struggle, but 50 minutes later the response was very feeble and in one hour it had disappeared. Five minutes after release of the aortic nerve stimulus and recovery of the blood pressure, there was a very faint response on sciatic stimulation, and in 40 minutes the response was of moderate degree. It appears that the cerebral cortical centers may be affected in advance of the vasomotor center.

SOMATIC NERVE IMPULSES

In case of accidental wounds afferent nerve impulses from the injured field that result in reflex lowering of blood pressure may pass over two sets of fibers. Afferent depressor impulses may pass to the vasomotor center in the medulla where they affect directly the vasodepressor mechanism. Pain impulses go to the cerebral cortex where in the conscious subject they frequently produce an adverse psychic effect that in turn results in a severe decline of blood and fainting from the passage of vasodepressor and cardiac inhibitor impulses from brain to medulla.

Clinical interest in these reactions centers in whether or not they may be of sufficient magnitude and duration to become a factor in the production of shock. Anesthesia precludes reflex vasodepression produced by painful impulses. Consequently, any fall in blood pressure produced by depressor nerve impulses from the injured field during operations on man under general anesthesia or in experiments on anesthetized animals would result from such impulses passing directly to the vasomotor center in the medulla. Both

animal experimentation and recent clinical experience in which the shock factor of blood and plasma loss is carefully guarded against by blood and plasma transfusions indicate that this mechanism is of little or no importance in the production of shock. A possible exception is abdominal manipulation in which there may be a fall of blood pressure by a mechanism that is imperfectly understood.

Rabbit 118 Wt 4.95 Kg Urethane 2.5 Gm i. p.

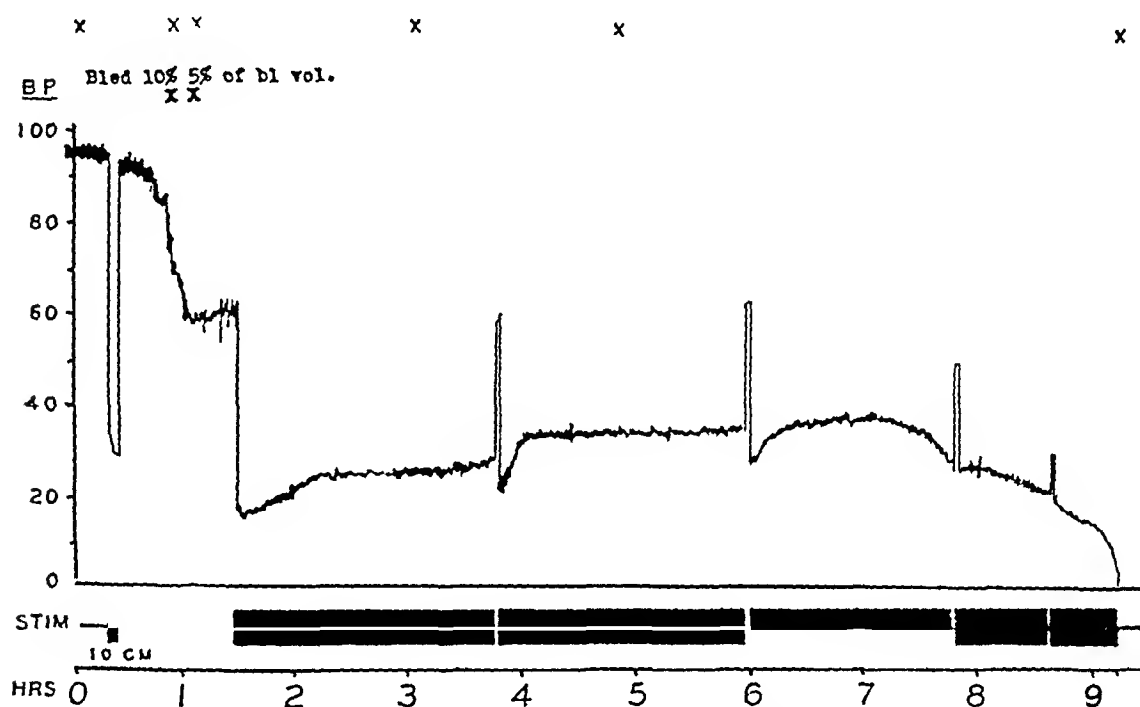


FIG 18—Rabbit 118. Small intermittent bleeding to shock level followed by further severe and extremely prolonged vasodepression from bilateral aortic depressor nerve stimulation.

In animal experiments^{11, 12, 13, 14} the direct exposure and stimulation of the central end of various somatic nerves of the extremities by electric currents of different strengths and frequencies produce a variety of pressor and depressor reactions. Most of them are of small magnitude and of brief duration, some examples of which are seen in Figure 21, Rabbit 140. Prolonged stimulation with either tetanizing or slow make and break shocks has not been demonstrated to produce a prolonged and sustained lowering of blood pressure and nothing remotely resembling a state of shock has resulted. On the contrary, with the stronger tetanizing currents after the initial sharp fall and rise or rise only, the blood pressure may either return to the former level or remain slightly elevated throughout a period of one or more hours' stimulation.

The effect on blood pressure of stimulation of the saphenous and sciatic nerves was determined in 12 rabbits, since this animal had been little used in reported experiments. The results were essentially the same as those reported for other animals. The result of only one experiment is included here.

Figure 22, Rabbit 152, illustrates the effect of three stimulation periods of approximately 125 hours duration by means of a shield electrode applied to the right sciatic nerve, with the secondary coil of the inductorium placed at eight cm from the primary. Onset of stimulation produced a relatively slight depression, then elevation and immediate return of pressure to pre-stimulation level of 100 Mm Hg. After 16 hours, the pressure had declined to 78 Mm and the stimulus was removed. No change in elevation occurred. Within 25 minutes, the pressure had risen to 82 Mm. The electrode was then adjusted and stimulus again applied for one minute and the same type of deflection occurred as was obtained at the start except that the degree was slightly

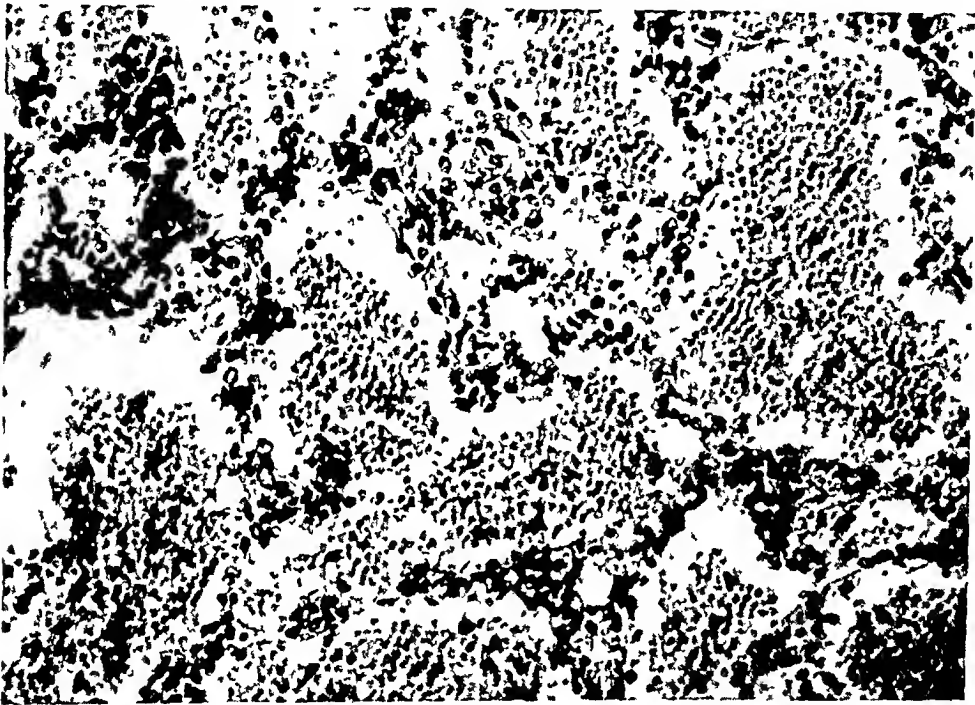


FIG 19—Rabbit 118 Congestion of spleen ($\times 450$)

greater. Beginning five minutes later, another 16-hour period of stimulation was given but very little pressure change resulted, the level dropping only from 82 to 78. An hour and a half rest followed, the pressure leveling at 86, and the stimulus was again applied at the same strength, producing a faint cry but no deflection. After 15 minutes the pressure had again dropped to 78 and the stimulus strength was increased to four cm. The pressure rose sharply to 100, declined to 80 in five minutes and reached 70 Mm Hg 20 minutes later, from which point it slowly rose to 74 within the next hour. The stimulus was then removed, and as no appreciable change occurred within the next 50 minutes, the animal was sacrificed.

Mechanical stimulation of the saphenous and sciatic nerves was produced by repeated pinching and crushing by means of a hemostat. The usual reaction to such strong stimulation was a quick rise in blood pressure of ten to 25 Mm Hg, with a decline to the vicinity of the previous level in two or

three minutes, and continued pinching would fail to keep the pressure significantly elevated

Stimulation was also carried out by rubbing and pinching the surfaces of large wounds made in the neck and thighs to resemble a severe accident. Small nerve fibers and effector organs were the structures stimulated and the response was variable but less pronounced than when large trunks were directly involved. Frequently the manipulations would produce a fall and rise in blood pressure of 15 to 20 Mm Hg lasting two or three minutes, following which the pressure remained at the previous level although the manipulations were continued. Sometimes there would be a brief decline followed by a rise,

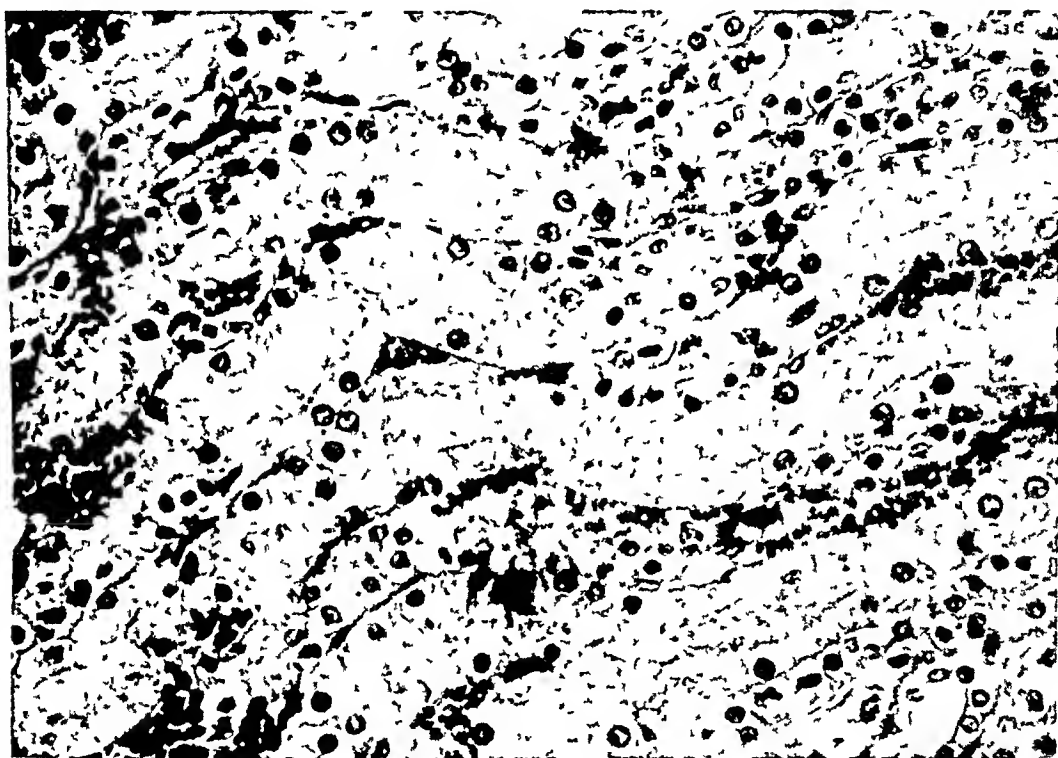


FIG. 20.—Rabbit 118. Mag. 500 diam. Congestion of kidney and necrosis of tubules (X 500)

or occasionally the order would be reversed, but in no case was a prolonged lowering of blood pressure produced in this way

In man the cutting, pinching, crushing and stretching of a large nerve as the sciatic has been continued for a few minutes during amputations. The procedure produces a slight rise in blood pressure and shock is not a sequela. Gentle handling of tissues during operations has long been advocated for the avoidance of shock that may arise from stimulation of the nerves in the field. Gentle handling is a very valuable teaching as it reduces trauma to the tissues, exudation into, and infection of, the wounds and favors wound healing. However, there is no well controlled evidence that it lessens the incidence of shock by decreasing the afferent depressor nerve impulses set up in the wound, except possibly in connection with upper abdominal operations.

It has been reported by O'Shaughnessy and Slome,¹⁵ and by Lorber, Kabat and Welte,¹⁶ that when a lower extremity of a dog has been severed except for the nerves and femur and the circulation maintained by either crossed circulation or perfusion with blood rendered noncoagulable, trauma then applied to the leg will cause the animal to have a decline in blood pressure and go into shock more readily than if the nerves had also been severed. Blalock and Cressman¹⁷ did not confirm these results except to report that spinal anesthesia reduced the tendency to shock when it was followed by general anesthesia produced by nembutal in cats and chloralose in dogs.

It is difficult to conceive a reason why nerve impulses capable of lowering blood pressure and producing shock would arise in the traumatized field of such a leg while direct electrical or mechanical stimulation of the proximal

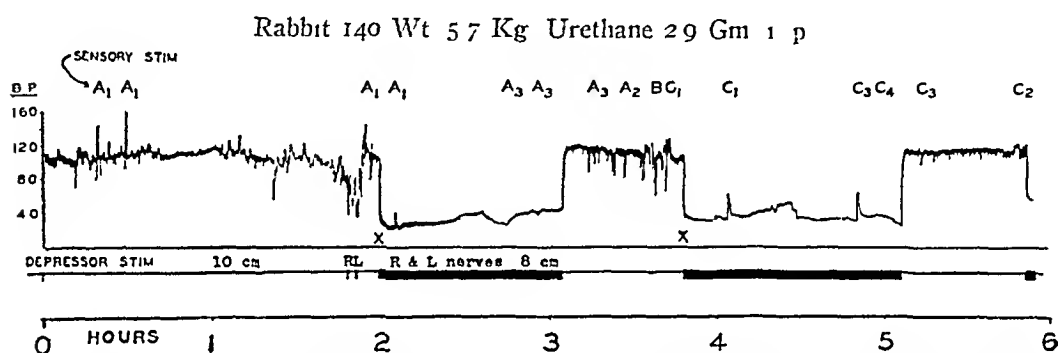


FIG 21—Somatic nerve stimulation with tetanizing current before, during, and after periods of vasodepression produced by stimulation of the aortic depressor nerve. A—Saphenous nerve stimulation, A₁—Struggles marked, A₂—Mild, A₃—None, B—Sciatic nerve cut, C—Sciatic nerve stimulated, C₁—Struggles marked, C₂—Moderate, C₃—Slight, C₄—None

end of the divided sciatic nerve fails to create such impulses. Parsons and Phemister¹⁸ found that denervation of the limb made no difference in the results when shock was produced by trauma to the lower extremity of the dog, the effect being due to local loss of circulating fluid.

Discussion—The outstanding feature of the aortic-depressor nerve stimulation experiments was the remarkable ability of the animals to tolerate long periods of low blood pressure produced by afferent depressor impulses without serious impairment of the circulation. When the stimulation producing vasodepression was continued the blood usually became diluted, as indicated by a gradual reduction in red cells, hematocrit, hemoglobin, plasma proteins, and oxygen and carbon dioxide content. In animals which died after a more prolonged period of vasodepression the necropsy findings revealed tissue damage from the hemodilution and anoxia. Some of the organs were congested and acute degenerative changes were found in the liver and kidneys.

The vasomotor center proved to be very resistant as shown by the prompt elevation and decline of pressure with each brief release of the stimulus. Failure of response developed gradually in the late stages of those experiments in which stimulation was continued until death. Both the hemodilution with

its anoxia and the stimulation appeared to damage the center and in some cases the latter was the more important factor, as shown by Figure 10, Rabbit 133. After three hours of marked vasodepression there was very feeble pressor response on release of the stimulus whereas a blood sample taken at the same time revealed extremely little hemodilution. Early death in Rabbit 147 (Fig 4) appeared to be due mainly to the stimulus which was produced by a relatively strong current.

RABBIT 152 WT. 4.7 KGM URETHANE 2.4GM. I.P.



FIG 22—Sciatic nerve stimulation with continuous tetanizing current at three intervals approximately 1.25 hours each

In some experiments prolonged release of the stimulus after hours of vasodepression to shock levels was followed by prompt return of the pressure to the previous level and the animal lived on much as if no stimulus had been applied. Also the blood which becomes diluted during the vasodepression may subsequently concentrate as shown in Figure 9, Rabbit 79.

The circulating blood volumes determined on five rabbits are probably only roughly accurate because of the variable conditions of the experiments and the inadequacy of the dye method. However, it appears from the data presented in Table V that any change in volume is in the direction of a slight decrease since the plasma volume was reduced in every experiment except one. The much reduced red cell mass appeared to be the result of trapping of cells in various structures as the spleen. In order to reconcile the coexistence of hemodilution and reduced circulating blood volume it is necessary to assume a loss of both plasma and water from the circulating blood which may be the result of capillary damage. Further studies on the water and electrolyte equilibria between blood and tissues and of the morphologic changes, including the central nervous system, are indicated.

Blood transfusion improved the circulation that had been impaired by prolonged vasodepression through nerve stimulation by increasing the circulating blood volume and the blood concentration. Plasma transfusion had a similar influence due to the increase in circulating volume and elevation of plasma proteins even though there was a further diminution of red cells, hemoglobin and hematocrit (Fig 13).

Bleeding after prolonged periods of low blood pressure from aortic-depressor nerve stimulation was somewhat damaging but relatively well tolerated, as indicated by the bleeding volumes that were obtained when the

animals were bled to death (Tables VI and VIII) Bleeding to shock levels before further lowering the blood pressure by stimulation of the aortic-depressor nerves tended to shorten the survival period to some extent (Table X)

In contrast with the marked and prolonged lowering of blood pressure and failure of the circulation which could be produced by aortic-depressor nerve stimulation, was the complete failure to produce such effects by direct exposure and stimulation of somatic nerves by pinching, crushing and use of electric currents of various strengths and frequencies

Syncope¹⁹ or fainting is the only definitely established condition in man in which afferent depressor impulses produce a rapid and marked fall of blood pressure closely approximating that produced in the rabbit by aortic-depressor nerve stimulation But fainting is a relatively short lived condition With loss of consciousness the subject passes to the recumbent position bringing heart and brain to the same level The circulation to the brain is thereby improved, the adverse psychic reaction is dispelled, the blood pressure rises and consciousness is regained within a few minutes The experiences of the clinic and of every day life show that fainting *per se* produces only temporary embarrassment of the circulation and does not lead to shock

Manipulations during upper abdominal operations^{20, 21} sometimes produce a fall in blood pressure and bradycardia that appear to be the result of afferent depressor nerve impulses but their pathways are as yet not well understood Numerous observations by one of us (D B P) indicate that such a fall in blood pressure in man is usually short-lived and passes off without damaging the circulation However, the low blood pressure occurring either in syncope or from abdominal manipulations if combined with a low blood pressure from hemorrhage might help to produce shock as did hemorrhage combined with aortic-depressor nerve stimulation in rabbits

The pathologic report of the tissues was kindly furnished by Dr Eleanor Humphreys

SUMMARY AND CONCLUSIONS

1 Stimulation of the aortic-depressor nerve of the rabbit may maintain the blood pressure at shock levels for hours without serious impairment of the circulation or of the body tissues However, if continued for a longer period it may produce death from the effects of hemodilution, anoxia and damage to the vasomotor centers, a condition which may be designated as neurogenic shock Plasma proteins are lost from the blood apparently as a result of capillary damage

2 Judging by the relative harmlessness of these long periods of low blood pressure in rabbits, by the inability to produce more than a brief slight lowering of blood pressure by direct stimulation of somatic nerves which carry impulses from traumatized fields and by the comparatively short duration of the periods of reflex lowering of blood pressure during syncope

and abdominal manipulations, it is extremely improbable that "primary shock" is ever produced in man by the action of afferent depressor nerve impulses

3 The use of the term "primary shock" to denote such a condition should be abandoned

4 When the blood pressure of the rabbit was first lowered to shock levels by hemorrhage and the aortic-depressor nerve then stimulated, the additional lowering of blood pressure would tend to hasten death to some extent. Also when the blood pressure was first maintained at shock levels for periods of one to four hours by aortic-depressor nerve stimulation and the rabbits then bled, there was usually some reduction in ability to tolerate blood loss

5 Judging from the results of combining hemorrhage and aortic-depressor nerve stimulation in lowering blood pressure and producing shock in rabbits, the occurrence in man of fainting or of a reflex fall of blood pressure from abdominal manipulation in the presence of low blood pressure produced by hemorrhage may constitute a contributing factor to shock. Clinical experience also supports this contention to some extent

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STUDIES ON TRAUMATIC SHOCK I—BLOOD VOLUME CHANGES IN TRAUMATIC SHOCK*

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DURING WORLD WAR I there was ample opportunity for a serious clinical study of traumatic shock. Many observations were made by competent groups of researchers in both the English and American medical corps. The experiences of these groups were reported by the joint English and American Research Councils, but the material was made more generally available by the publication of Cannon's¹ important monograph "Traumatic Shock" in 1923.

Since that time, although the remarkably thorough and painstaking investigations of Blalock directed attention to the importance of local blood loss as a causative factor in traumatic shock, no studies have been made on the blood volume of patients in shock as a result of trauma.

With the advent of the present global war, attention was again drawn to the urgent need for more data on clinical shock. By this time accurate clinical observations could be correlated with the blood volume of patients in shock because of the development of an adequate method by Gregersen, in 1935, for the estimation of plasma volume.

The present communication is a report of the estimation of plasma volume in a considerable number of patients in shock as a result of various types of trauma, and an attempt to correlate these blood volume studies with the manifestation of shock signs in these patients. We have tried to determine the relative importance of blood loss as an initiating and sustaining factor in traumatic shock.

We are fortunate in having at our disposal a considerable amount of clinical shock material very similar to the shock-patient group seen in modern warfare. One of our hospitals cares for a large urban Negro population, mostly of lower economic levels. The injuries sustained by these persons are caused, in general, by knife and gunshot wounds of the extremities, chest and abdomen. To this group of shock cases has been added a considerable number of traumatic injuries of the skeletal structures caused by automobile and industrial accidents.

THE ESTIMATION OF PLASMA VOLUME IN THE SHOCK STATE

There has been considerable hesitancy on the part of research workers

* This study was carried out under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research & Development and The Medical College of Virginia. It was initiated by a grant from the Committee on Medical Research of the American Medical Association.

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BLOOD VOLUME IN TRAUMATIC SHOCK

CHART 1

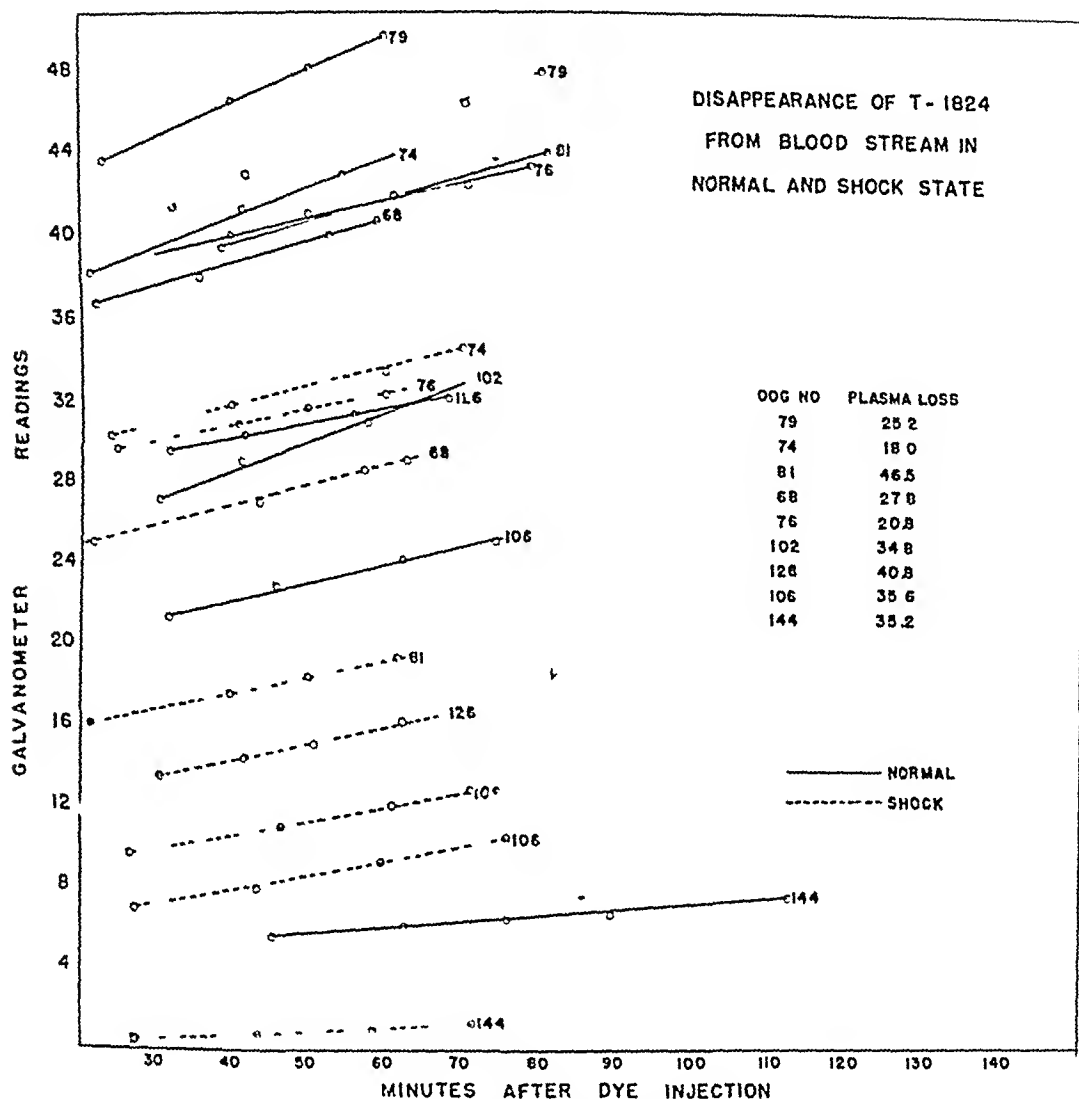


CHART 1—Disappearance rate of dye T-1824 from the blood stream of dogs during normal state and in shock from intestinal strangulation. The disappearance rates are practically identical, suggesting that there was no generalized increase in capillary permeability in the shock state.

to attempt the determination of plasma volume in the shock state, because of the current belief that there is in shock an increased capillary permeability. This generalized increase of capillary permeability, some maintain, will cause the injected dye to be lost from the vascular system into the tissue spaces rapidly, and in amounts great enough to seriously disturb the disappearance curve of the dye.

Insofar as we can find, the first determinations of plasma volume during the shock state were made by Keith,² and Robertson and Bock,³ working for the Shock Committee during World War I. These investigators employed the vital red dye method of Keith, Rowntree and Geraghty,⁴ and were able to demonstrate a rather serious depletion of plasma volume in wounded soldiers suffering from traumatic shock.

Following World War I, interest in the determination of plasma volume waned, probably due to the fact that considerable doubt was cast on the validity of the vital red method for the determination of plasma volume,

TABLE I
ACUTE BLOOD LOSS
Shock—None or Mild

Patient	Blood Pressure	Pulse Rate	Pulse Quality	Venous Filling	Extremities		Plasma Volume	Hemato-crit	Plasma Protein
					Temp	Sweat			
B E	110/80	120	Good	Good	Warm	Dry	39	42	6 8
B N	118/80	112	Poor	Poor	Cold	Dry	41	34	6 4
M C	100/60	92	Good	Good	Warm	Dry	38	31	7 7
J R	90/60	76	Poor	Good	Warm	Dry	45	43	6 8
A C	110/80	76	Good	Good	Warm	Dry	41	41	6 8
J F	80/60	68	Good	Poor	Warm	Moderate	38	39	5 7
R A	100/60	82	Fair	Good	Warm	Dry	42	39	6 6
J H	120/80	80	Good	Good	Warm	Dry	41	40	6 5
C C	92/66	80	Fair	?	Cold	Moderate	35	42	6 6
J R	68/48 to 130/90	64	Good	Good	Warm	Dry	42	32	5 4
A S	92/70	96	Good	Good	Warm	Dry	35	44	6 9
<i>Moderate or Severe</i>									
L H	Unobt	160	Poor	Poor	Cool	Moderate	20	32	5 4
B P	90/60	150	Poor	Poor	Cool	Dry	28	27	6 6
V B	45/0	130	Poor	Very poor	Cold	Marked	24	34	6 9
D G	75/50	126	Fair	Good	Cold	Moderate	28	24	7 1
M K	65/50	120	Poor	Very poor	Cool	Marked	26	31	6 6
L D	68/58	130	Poor	Poor	Warm	None	26	28	6 9
O S	80/60	72	Fair	Poor	Warm	Dry	25	27	4 9
A R	60/40	80	Poor	?	Warm	Marked	33	41	6 3
W R	80/50	108	Poor	Poor	Cool	Dry	31	44	6 8
C J	65/20	90	Poor	Poor	Cold	Marked	26	35	6 0
T D	110/80	130	Fair	Poor	Cold	Dry	28	45	5 5
A G	80/40	92	Fair	?	Warm	Dry	31	35	6 7
C G	62/20	90	Fair	Fair	Warm	Marked	38	35	6 0

even in the normal state. It was not until Gregersen⁵ developed and standardized the dye method which employs the dye T-1824, called by some "Evans' blue dye," that much recent work has been done on the determination of plasma volume. Gregerson, Gibson and Stead,⁶ employing the spectrophotocolorimeter, were able to show conclusively that estimations of plasma volume could be made by this method if it were used in the manner outlined by them. Later, Gibson and Evelyn⁷ adapted this method to use the Evelyn photoelectric colorimeter, this, in the minds of some, has simplified considerably the estimation of plasma volume.

There have been few published studies on the use of the Gregersen-Gibson method for the determination of plasma volume during the shock state. The observations of Freeman, and his coworkers,⁸ who used this method in experimental shock produced by continuous adrenalin infusion, have cast some doubt on the validity of the T-1824 method for the determination of plasma volume during shock. These workers found the dye in the pericardial lymph and other tissue fluids, one could infer from their observations that there might be rather disturbing losses of the dye from the vascular system during shock, losses possibly so great as to disturb seriously the disappearance curve of the dye.

The majority of our observations with the Gregersen-Gibson method for the estimation of plasma volume during the shock state have been made in patients in clinical traumatic shock and in the experimental shock prepara-

tion, described earlier by one of us,⁹ namely, the production of shock by the strangulation of a short loop of ileum

In Chart 1 is shown the dye disappearance curves in ten dogs in the normal and in the shock state. The solid line represents the disappearance curve of the animal in the normal state while the broken line represents the dye disappearance curve for the same animal after it had lost enough plasma to put it into more or less severe shock. At the right of each disappearance curve is given the number of the animal. It will be noted that the dye disappearance curves in both the shock and normal state practically parallel each other for the same animal.

In Chart 2 are given a small number of dye disappearance curves for human patients in severe shock compared with several disappearance curves found in patients with normal blood volumes. It will be seen that the dye disappearance rate is practically the same whether the patient is in severe shock or not. In several instances in patients in severe traumatic shock we have found increased dye disappearance rates. However, when the plasma volume determination was carried out on the following day we would often get a high dye disappearance rate even though the patient then showed no evidence of clinical shock.

Our experience with the use of the Gregersen-Gibson method for the estimation of plasma volume in well over 500 plasma volume determinations in the shock and normal states in patients has convinced us that the method gives valid data for the estimation of plasma volume during the shock state. The dye disappearance rates in clinical shock offer no evidence that would lead us to believe that there is generalized increased loss of the dye through the capillary wall in clinical traumatic shock.

Analysis of many dye disappearance rates in normal and shock patients has convinced us that for clinical purposes one can estimate plasma volume rapidly by using only one plasma sample, taken ten minutes after the injection of the dye. This, likewise, has been the experience of Gregersen, and his coworkers,¹⁰ and Shaefer.¹¹ Throughout this research, however,

CHART 2

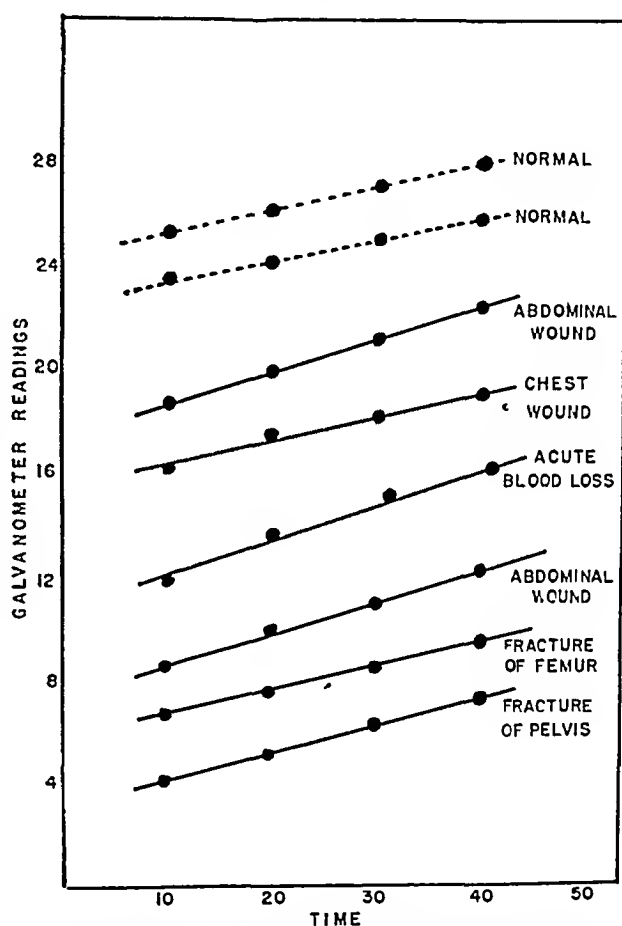


CHART 2—Disappearance rate of dye T-1824 from the blood stream of human subjects during the state of traumatic shock

TABLE II
SKELETAL TRAUMA
Shock—None or Mild

Patient	Diagnosis	B P	Pulse Rate	Pulse Quality	Venous Filling	Extremities		Plasma Volume	Hemato- crit	Plasma Protein
						Temp	Sweat			
P J	Compd fract tibia fibula	140/80	72	Good	Good	Warm	Dry	39	42	7 0
D T	Fract femur	120/80	80	Good	Good	Warm	Dry	45	42	7 0
A O	Fract pelvis	110/70	90	Good	Good	Warm	Dry	38	40	6 7
M N	Compd fract tibia fibula	124/82	90	Good	Good	Warm	Dry	39	37	6 5
O R	Compd fract femur tibia	110/68	60	Good	Good	Warm	Dry	42	47	7 0
H C	Fract femur	128/80	80	Good	Good	Warm	Dry	46	46	7 7
E T	Gunshot wound compd fract of shoulder	120/80	76	Good	Good	Warm	Dry	40	43	7 2
Γ B	Fract tibia, fibula	90/50	80	Fair	Fair	Warm	Dry	40	34	7 0
I D	Fract pelvis	120/70	90	Good	Good	Warm	Dry	45	39	7 2
T D	Fract femur	130/80	84	Fair	Good	Warm	Dry	43	43	7 5
F F	Dislocated hip	130/90	90	Good	Good	Warm	Dry	31	47	6 9
M M	Fract femur knee laceration	110/65	104	Fair	Fair	Sl cool	Dry	32		6 7
S T	Compd fract tibia fibula	142/110 to 90/50	112	Fair	Good	Warm	Dry	29	34	7 2
J C	Fract femur tibia, fibula	90/60 to 110/60	72	Good	Good	Warm	Dry	35	37	7 0
G S.	Compd fract of femur	90/60	70	Good	Good	Warm	Dry	38	46	6 3
R M	Fract of femur	96/64	100	Fair	Fair	Cool	Dry	25	33	6 1
S H	Compd fract of femur	80/60	100	Fair	Fair	Cold	Moderate	32	49	7 1
A J	Fract femur	184/90	80	Good	Good	Warm	Dry	48		6 9
C W	Fract femur	110/80	88	Good	Good	Warm	Dry	40	38	7 0
L H	Traumatic amp of arm	130/90	82	Good	Good	Warm	Dry	41	44	6 2
E M	Fract femur basal skull fract	120/80	78	Good	Fair	Warm	Moderate	43	40	6 5
L A	Gunshot wd fract femur	90/70	76	Fair	Good	Warm	Dry	42	40	7 0
J C	Fract femur radius & ulna	70/58	65	Good	Fair	Warm	Dry	45	33	5 3
W F	Compd fract tibia fibula	120/80		Good	Good	Warm	Dry	42	44	6 7
E W	Fract pelvis	110/70		Good	Fair	Warm	Dry	38	40	6 9
P H	Fract pelvis	130/80		Good	Good	Warm	Dry	42	39	7 1
J A	Fract femur	130/90 to 80/60	80	Good	Good	Warm	Dry	32	43	7 7
J B	Fract femur	80/60 to 110/60	96	Good	Good	Warm	Dry	36	46	7 5
<i>Moderate Shock</i>										
B L	Fract femur	90/60 to 70/50	56	Poor	Good	Warm	Dry	28	36	6 3
L F	Fract femur scapula	90/60	80	Good	Good	Cold	Marked	25	48	6 8
E S	Compd fract tibia fibula	136/68	118	Good	Good	Warm	Marked	31	39	5 9
R H	Fract femur	70/45	100	Fair	Fair	Cool	Moderate	25	42	6 1
T L	Compd fract tibia fibula	92/50	76	Good	Good	Cool	Dry	25	48	6 6
J H	Compd fract of femur	60/40	60	Poor	Fair	Cold	Dry	31	49	6 5
G R	Fract tibia, fibula	80/40	80	Poor	Fair	Cold	Dry	31	39	6 9
N F	Fract pelvis, & scapula	104/60	120	Poor	Poor	Cold	Marked	31	31	6 0
T W	Fracture of pelvis	70/50	136	Poor	?	Cold	Marked	36	38	6 1
L M S	Traumatic amputation ft compd fract tibia & fibula	75/40	68	Fair	?	Cool	Marked	32	43	6 6
<i>Severe Shock</i>										
H L	Traumatic amp of leg	130/50 to 70/50	100	Fair	Good	Cold	Marked	29	38	5 9
P R	Fract pelvis	80/60	110	Fair	?	Cold	Marked	25	47	7 5
D H	Fract femur & fibula	70/50	110	Poor	Poor	Cool	Marked	30	39	5 6
J W	Compd fract of tibia fibula fract pelvis	125/60 to 75/50	110	Good	Good	Warm	Dry	25	31	7 3
H G	Compd fract of femur	58/40	140	Poor	Very poor	Cold	Marked	26	38	6 0

BLOOD VOLUME IN TRAUMATIC SHOCK

TABLE II—(Continued)

Patient	Diagnosis	B P	Pulse Rate	Pulse Quality	Venous Filling	Extremities		Plasma Volume	Hemato crit	Plasma Protein
						Temp	Sweat			
J W	Fract both ankles, compd fract of humerus	80/50	108	Very poor	Poor	Cool	Moderate	32	42	6.9
C H	Compd fract both tibia, fibula	165/95 to 120/80	100 to 136	Fair	Fair	Cold	Moderate	26	44	5.4
F L	Compd fract tibia, fibula, fract of humerus	60/?	130	Poor	?	Cold	Dry	25	46	6.9
E K	Compd fract tibia fibula	82/70	116	Poor	?	Warm	Dry	18	44	7.1
H M	Crushed pelvis	60/40	160	Poor	Poor	Warm	Dry	26	33	6.6
S C	Fract femur & pelvis	88/60	100	Fair	Poor	Cold	Dry	25	38	?
R T	Fract pelvis & unobt femur		120	Poor	Fair	Cold	Dry	24	?	?
E G	Multiple compd fract of legs fract pelvis	90/60	88	Poor	Poor	Cool	Dry	28	?	?
L G	Fract femur	80/40	90	Fair	Poor	Cool	Moderate	26	32	5.4
H T	Comp fract femur	80/45	108	Poor	Fair	Cool	Dry	35	42	6.7
W C	Fract tibia, fibula	70/30	110	Poor	Poor	Cold	Moderate	28	42	?
A T	Fract femur & lumbar vertebra	56/0	90 to 150		Poor?	Cool	Dry	22	?	?

we have tried to get at least four to six samples after the injection of the dye, so that we could estimate the dye disappearance rate

Of importance is the fact that in this study all blood samples were taken without the use of the tourniquet. In patients in severe shock it is necessary to draw the blood samples from either an artery or the femoral vein. It has been our custom recently to use the femoral vein for blood sampling almost routinely in patients in severe shock so that the blood is drawn without any stasis.

Hematocrit estimations were made using the Sanford-Magath six-cubic centimeter graduated centrifuge tube, total protein was determined by the Kagan¹² method, which employs the falling-drop principle.

THE RELATION OF PLASMA VOLUME TO CLINICAL SHOCK

A well-organized city ambulance service enables us to observe our shock patients fairly soon after the injury has been received, as a result of which we have been dealing largely with patients in relatively early shock. The patients were brought directly to the Emergency Rooms, where they were placed immediately on a stretcher in the head-down position. No treatment was administered until after the arrival of a member of the "shock team" who were on 24-hour call. As soon as a hasty diagnosis and estimate of the likely severity of shock was established, a plasma volume determination was begun.*

During the time required to secure serial blood samples, clinical observations on the early signs of shock were made and recorded. These observations will be discussed in a subsequent section of this paper.

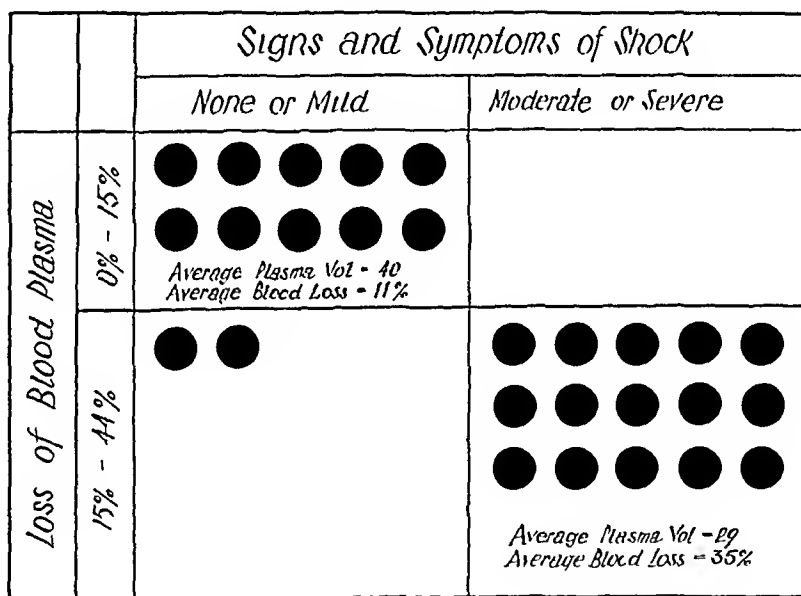
For convenience of analysis and presentation, we have classified our shock cases into four groups: (1) Acute blood loss, (2) skeletal trauma,

* We are grateful to Dr. Marvin Thompson of the Warner Institute for Therapeutic Research for liberal supplies of the dye T-1824.

(3) abdominal injuries, and (4) chest injuries. In the early part of this clinical study, we were called to see only patients in actual shock, but soon it became obvious that we should attempt to see and study all patients who had suffered severe traumatic injury, whether or not signs of shock were present. Thus, we are able to compare two groups of patients: (a) Those who had no signs of shock or only signs of mild shock, and (b) patients in moderate or severe shock. In general, the types of injury were the same in both groups. (See Tables I-IV)

The *acute blood loss* group is made up of those patients who suffered more or less severe loss of blood from lacerations of peripheral arteries and veins (usually as a result of knife or razor wounds). These wounds were not complicated by muscle trauma. The *skeletal trauma* group consists of all

CHART 3
Acute Blood Loss



Each disk represents one patient

CHART 3—Scattergram showing the relation of blood loss to severity of shock in simple acute blood loss

patients who suffered any of the following fractures: Fractures, simple or compound, of the pelvis, femur, or tibia and fibula. The *abdominal injuries* consisted mainly of gunshot or stab wounds (perforating) of the abdominal cavity, also included are several patients with traumatic rupture of the small intestine. The *chest injury* group included all stab and gunshot wounds of the thorax, along with those patients with crushing injuries of the chest. The shock picture in this group is complicated many times by coexisting pneumothorax.

In Tables I, II, III and IV have been placed much of the collected data on this large group of 143 patients who have suffered traumatic injury. Space does not allow for an inclusion in these tables of all the clinical

BLOOD VOLUME IN TRAUMATIC SHOCK

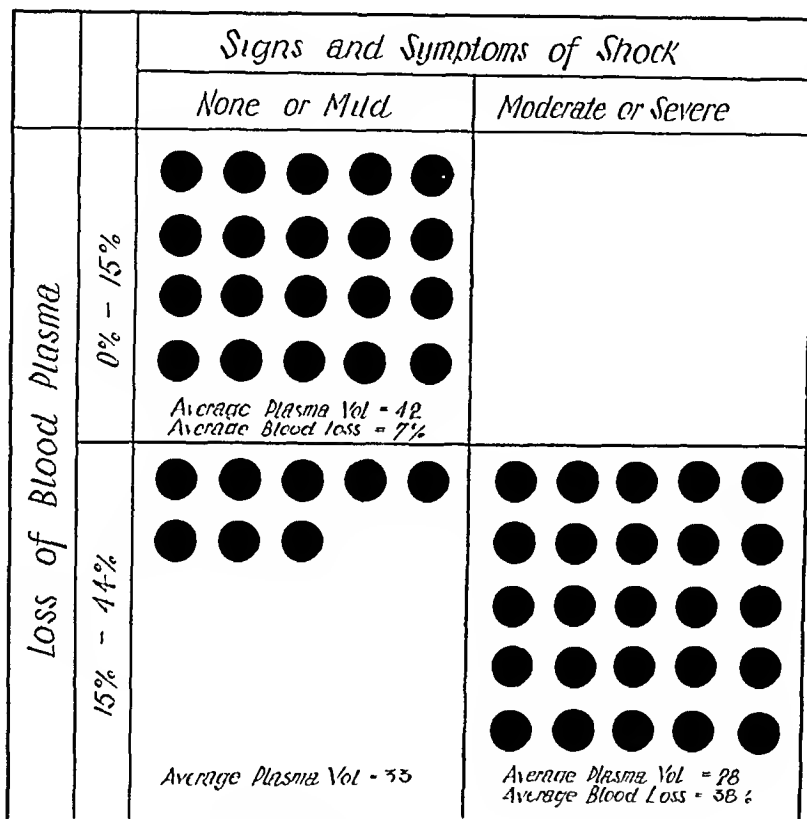
TABLE III
CHEST INJURY
Shock—None or Mild

Patient	Diagnosis	B P	Pulse Rate	Pulse Quality	Venous Filling	Extremities		Plasma Volume	Hemato- crit	Plasma Protein
						Temp	Sweat			
M P	Stab wound hemothorax	88/58 to 120/70	102	Good	Good	Warm	Dry	41	37	5.9
G B	Stab wound	90/70 to 110/80	78	Good	Fair	Warm	Dry	44	33	6.7
M P	Bullet wound hemothorax	132/80	80	Good	Good	Warm	Dry	38	35	6.5
A H	Bullet wound chest	130/68	90	Good	Good	Warm	Dry	38	40	?
N L	Stab wound hemothorax	80/60	92	Fair	Fair	Cold	Dry	38	39	?
J B	Stab wound	90/70 to 110/70	120	Fair	Fair	Warm	Dry	40	44	7.2
J M	Stab wound	90/60	120	Fair	Poor	Warm	Moderate	35	36	5.4
B G	Bullet wound	120/80	80	Good	Good	Warm	Dry	38	40	6.2
<i>Shock—Moderate or Severe</i>										
C G	Stab wound hemothorax	80/60	98	Good	Fair	Warm	Dry	29	43	7.0
B B	Stab wound hemopneumothorax	60/20	88	Fair	Good	Warm	Marked	29	43	?
L P	Bullet wound hemopneumothorax	50/28 to 80/58	96	Poor	Fair	Cold	Marked	29	43	6.1
W C	Stab wound, hemopneumothorax	60/40	95	Fair	Fair	Warm	Marked	33	44	5.7
*H S	Multiple rib fractures, axillary vein rupture	165/100 to 70/50	108	Fair	Poor	Cold	Marked	31	37	6.5
E G	Stab wound, hemopneumothorax	65/45	100	Poor	Poor	Warm	Marked	26	44	6.7
R W	Gunshot wound chest and abdomen	50/?	160	Poor	Poor	Cold	Marked	31	45	6.8
D F	Crushed chest	110/80 to 70/50	70	Good	Fair	Cold	Dry	22	46	6.9
I P	Crushed chest	50/0	84	Poor	?	Cold	Dry	25	46	7.8
E B	Multiple fract., ribs	70/50	72	Poor	?	Cold	Dry	31	46	6.7
E H	Bullet wound, hemothorax	50/20	130	Poor	Fair	Warm	Dry	27	39	6.2
J C	Bullet wound hemopneumothorax	70/40	128	Poor	Fair	Cold	Dry	26	36	5.8
E W	Stab wound, hemothorax	50/? to 80/60	120-102	?	?	Cold	Marked	29	49	7.0
W R	Shotgun wound cardiac tamponade	60/40	96	Poor	Good	Cold	Marked	42	45	7.0
L H	Stab wound hemothorax	Unobt	73	Very poor	Fair	Cold	Dry	26		
J E	Fract ribs, massive hemothorax	40/?	150	Poor	Poor	Cold	Marked	25	45	?
E M	Bullet wound aorta & heart, massive hemothorax	60/40	110	Poor	Poor	Cold	Marked	25	43	7.2
J F	Fract of 5 ribs hemopneumothorax	75/45	76	Poor	?	Cold	Dry	28	39	?
R W	Bullet wound, hemopneumothorax	50/?	160	Poor	Fair	Cold	Dry	32	44	6.8
W J	Stab wound sucking pneumothorax	70/50	90	Fair	Fair	Warm	Dry	31	41	7.4
W B	Stab wound, hemopneumothorax	60/40	88	Poor	?	Cold	Marked	39	36	6.0
J B	Bullet wound internal mammary artery	unobt	100	Poor	Poor	Cold	Marked	20	44	6.9
*C A	Fract sternum, contusion of heart	60/40	63	Poor	Good	Cool	Dry	45	44	7.2
H F	Contusion of heart	60/30	65	Poor	Poor	Cool	Dry	45	44	7.2
S B	Stab wound internal mammary artery	65/45	68	Poor	Poor	Warm	Dry	28	43	6.9

data collected on the individuals of this group. The great majority of the patients were young or middle aged, and colored. References can be made to these tables for the pertinent shock data on these patients, such as early clinical signs of shock (which will be discussed below), plasma volume, hematocrit, and total plasma protein in per cent.

I *Plasma Volume* in Acute Blood Loss*—For purposes of ready analysis, plasma volume data on the individual groups have been arranged in scatter-

CHART 4
Skeletal Injury



Each disk represents one patient

CHART 4—Scattergram showing the relation of blood loss to the severity of shock in skeletal trauma

gram fashion. In Chart 3 it will be seen that in the patients with acute blood loss in whom shock was absent, or only mild, the average plasma volume was 40 cc Kg, representing an average blood loss of only 11 per cent. In the acute blood loss group where shock was moderate or severe, the average plasma volume was 29 cc Kg, representing an average blood loss of 35 per cent.

II *Plasma Volume in Skeletal Trauma*—In the scattergram shown in Chart 4 that group of the skeletal trauma patients who showed no, or only

* We have accepted 45 cc Kg as the normal figure for plasma volume for adults (Gregersen, and our unpublished data)

BLOOD VOLUME IN TRAUMATIC SHOCK

TABLE IV
ABDOMINAL INJURIES
Shock—None or Mild

Patient	Diagnosis	B P	Pulse Rate	Pulse Quality	Venous Filling	Extremities		Plasma Volume	Hemato- crit	Plasma Protein
						Temp	Sweat			
J M	Gunshot wound	90/70	120	Fair	Good	Warm	Mild	39	44	6 0
J K	Gunshot wound	95/60 to 110/70	80	Good	Good	Warm	Dry	32	46	7 0
M A	Gunshot wound	130/70	90	Good	Good	Warm	Dry	38		
S P	Gunshot wound	140, 100	90	Good	Good	Warm	Dry	43	45	7 0
L T	Stab wound	128/80	114	Good	Good	Warm	Dry	39	43	6 2
E G	Gunshot wound	105/70 to 90/60	78	Good	Good	Cold	Dry	38	40	6 2
J B	Gunshot wound	132/90	96	Good	Good	Warm	Dry	43	54	7 2
B A	Gunshot wound	110/85	75	Good	Good	Warm	Dry	39	41	6 8
S R	Gunshot wound	120/80	80	Good	Good	Warm	Dry	35	48	6 2
L F	Gunshot wound	124/84	123	Good	Good	Warm	Dry	43	43	6 8
D G	Stab wound of liver	120/80 to 80/60	100	Fair	Good	Warm	Dry	39	43	6 8
E P	Gunshot wound	130/80	98	Good	Good	Warm	Dry	46	44	6 9
A M	Stab wound late periton	130/70	98	Good	Good	Warm	Dry	24	31	6 3
J T	Gunshot wound	140/100	95	Fair	Poor	Warm	Dry	28	49	6 4

Shock—Moderate or Severe

W S	Gunshot wound	84/60 to 120 64/35	Fair	Good	Warm	Dry	32	44	6 2
O H	Ruptured ileum (traumatic)	60/40 100	Poor	Fair	Warm	Dry	24	55	5 6
M T	Gunshot wound	60/40 95	Fair	Fair	Cool	Dry	28	43	6 8
A M	Rupt jejunum (traumatic)	75/50 120	Poor	Poor	Cold	Marked	22	51	7 2
R J	Stab wound liver	50/35 100	Poor	Poor	Cold	Dry	28	38	5 9
C H	Rupt bladder, peritonitis	140/120 155	Poor	Poor	Cool	Dry	25	57	?
M J	Stab wound	50/0 140	Poor	Poor	Cold	Marked	25	37	5 6
W W	Rupt jejunum (traumatic)	90/40 160	Poor	Poor	Cold	Marked	18	60	7 3
H G	Gunshot wound	110/70 120	Poor	Poor	Cold	Dry	32	40	?
J M	Stab wound	to 70/50 120/80 100	Good	Good	Warm	Dry	34	41	6 9
G M	Peritonitis	to 60/40 Unobt Unobt	Unobt	Poor	Cold	Marked	25	44	5 5
A C	Stab wound	80/50 84	Good	Good	Warm	Moderate	32	45	7 2
M B	Rupt uterus	130/70 78	Good	Good	Warm	Dry	29	32	6 0
L A	Gunshot wound	to 60/30 70/50 88	Fair	Fair	Warm	Mild	31	40	5 8
L S	Stab wound	84/45 70	Fair	Good	Cool	Dry	32	27	7 0
J M	Stab wound	105/70 96	Good	Good	Cold	Marked	30	36	5 8
		to 80/60							

mild, signs of clinical shock have an average plasma volume of 42 cc Kg, which represents an average blood loss of only 7 per cent. On the other hand, in those skeletal trauma patients in whom shock was moderate or severe, the average plasma volume was 28 cc Kg, which represents an average blood loss of 38 per cent.

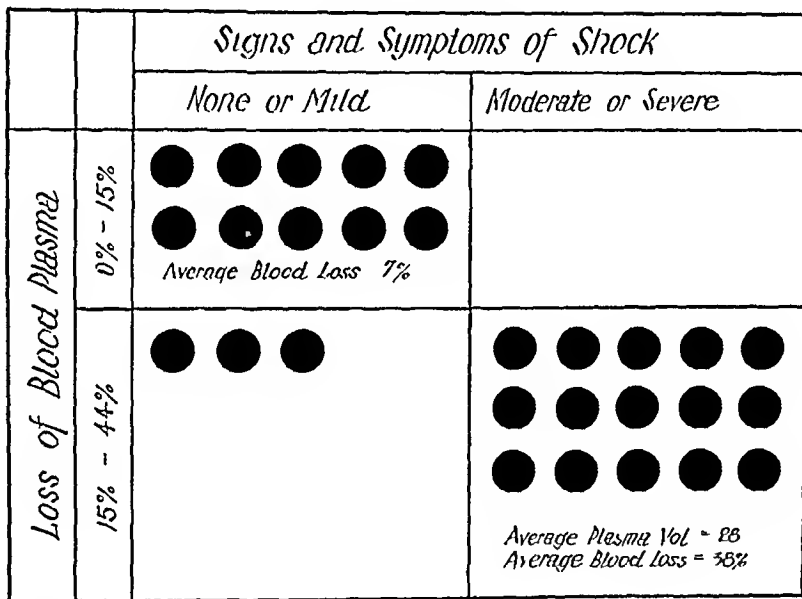
III *Plasma Volume in Abdominal Injuries*—In the scattergram shown in Chart 5 it will be noted that the plasma volume of the "none or mild" shock group is 42 cc Kg, representing an average blood loss of only 7 per cent, while in the moderate or severe group, the average plasma volume is 28 cc Kg, or a represented blood loss of 38 per cent.

IV *Plasma Volume in Chest Injuries*—The study of shock in chest injuries is complicated by at least three important factors, other than blood

loss Patients may receive heart wounds such that little or no external or internal blood loss occurs, but cardiac tamponade results Secondly, direct trauma over the precordium may result in cardiac contusion, from which shock may result Thirdly, the presence of a large pneumothorax, open or closed, complicates and makes more severe any shock, especially when the attendant large blood loss is great

It will be seen (see Chart 6), therefore, that patients in the chest injury group showing little or no signs of shock have an average plasma volume of 40 cc Kg, which represents a blood loss of only 11 per cent, while in the group showing signs of moderate or severe shock, there are two patients

CHART 5
Abdominal Wounds



Each disk represents one patient

CHART 5—Scattergram showing the relation of blood loss to the severity of shock in abdominal wounds

with cardiac tamponade, and two with cardiac contusion, who lost very little blood However, in all chest injury patients in whom blood loss was a real factor in the production on shock, the average plasma volume was 28 cc Kg, which represents a blood loss of 38 per cent

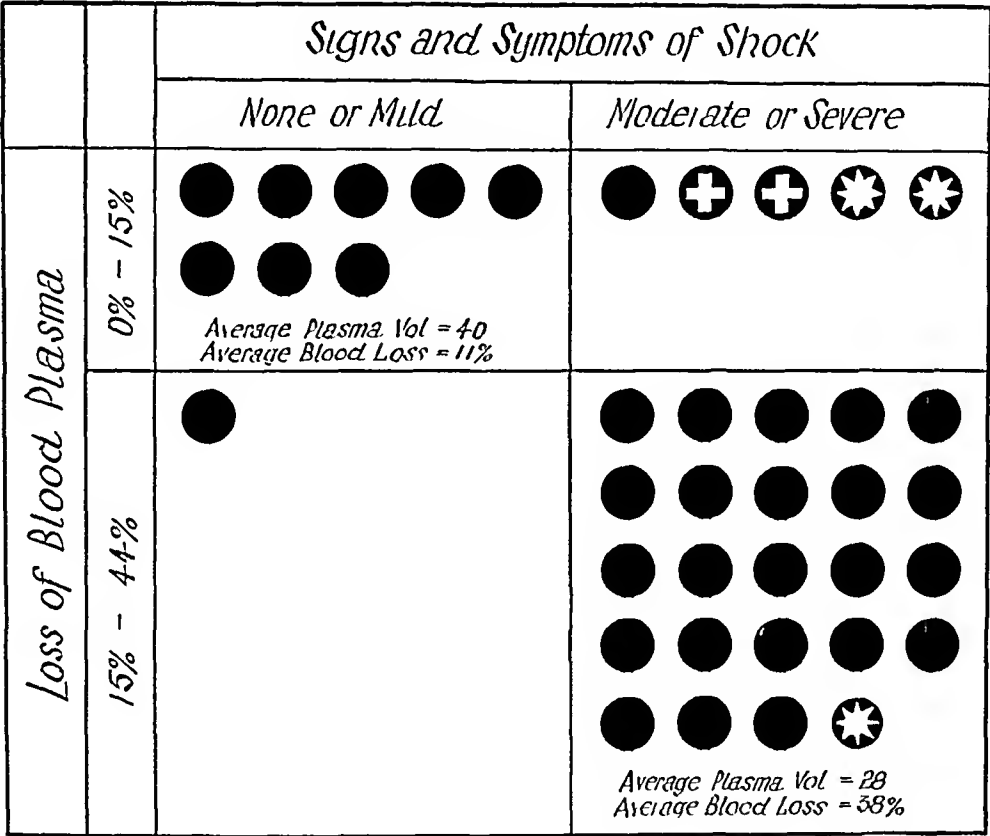
WHAT IS LOST FROM THE BLOOD STREAM IN SHOCK?

Chart 7 represents a diagram of the hematocrit values of these patients A study of this chart will indicate to the reader that, in the main, the hematocrit values (the average of 3-6 individual readings taken during the plasma volume determination) show little evidence of hemoconcentration Hence, it is readily evident that what is lost from the blood stream early in shock as a result of trauma must be *whole blood* and not its liquid component,

plasma The protein figures (to be found for the individual patient in Tables I-V) indicate that if dilution of the blood is taking place by drawing in of fluids from the extravascular spaces to compensate for blood loss, the diluting fluid must closely simulate plasma

Because of the hematocrit values obtained in this study, we believe we are justified in calculating from our plasma volume data an estimate of whole blood loss which, as has been seen in the various groups of shock

CHART 6
Chest Injury



Each disk represents one patient
Each white star = stab wound of heart
Each white cross = cardiac contusion

CHART 6—Scattergram showing the relation of blood loss to the severity of shock in chest injuries

patients studied, is for the “moderate and severe” groups, 35 per cent, 38 per cent, 38 per cent and 38 per cent, respectively

It will be noted in Charts 3-6 that several patients, especially in the skeletal trauma group, showed no, or only mild, signs of shock even though the blood loss was greater than 15 per cent In these patients it is evident that physiologic adjustment to blood loss (other than fluid replacement to the vascular system) was rapidly made It is noteworthy, however, that only one patient of the entire series (in the chest injury group) showed signs of moderate or severe shock with a blood loss of less than 15 per cent

In the abdominal injury group, it will be noted on Chart 7, that five patients

had hematocrit readings above 50 per cent. Reference to Table III will show that four of these patients had a ruptured viscus (three—ruptured small bowel, one—bladder). These studies suggest that if a patient is seen in shock with a gunshot wound of the abdomen and the hematocrit value is above 50, the chances are fair that there has been a perforation of a viscus, with peritonitis resulting.

THE EARLY CLINICAL SIGNS OF TRAUMATIC SHOCK

Because of the relative scarcity of information on the *early* clinical signs of shock we have endeavored to collect observations on these points.

(a) *Blood Pressure Readings*—Blood pressure readings were made on the arm, using a pneumatic cuff and a standardized mercury manometer. At

CHART 7

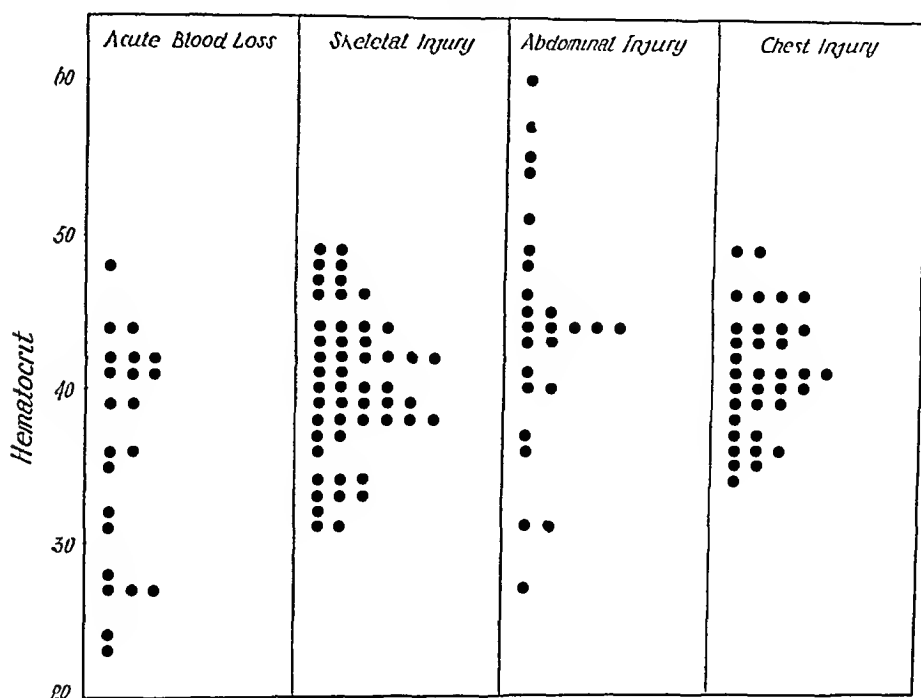


CHART 7—Scattergram showing the average hematocrit readings in clinical shock produced by acute blood loss, skeletal trauma, abdominal wounds and chest injuries. Except for the five patients in the abdominal injury group (mentioned in text), there is no indication of hemoconcentration early in the shock state. This suggests the loss of whole blood, rather than plasma alone, early in the shock state.

least three or four readings were made during the hour—sometimes more. It is emphasized that these readings are made with the patient in the moderate Trendelenburg head-down position (usually about 15°).

(b) *Pulse Rate and Pulse Quality*—Pulse rate and quality were recorded from the radial pulse and usually checked (rate) at the precordium.

(c) *Venous Filling Time*—This simple test, as employed by us, consists of emptying by pressure stroking of the finger one or more of the visible veins in the outstretched, ventral surface of the forearm and noting the time taken by the vein to refill. Although this is admittedly a crude indicator of peripheral blood flow to an extremity, this test has, at times, given us valuable information as to the severity of shock present, especially in

BLOOD VOLUME IN TRAUMATIC SHOCK

CHART 8
Acute Blood Loss

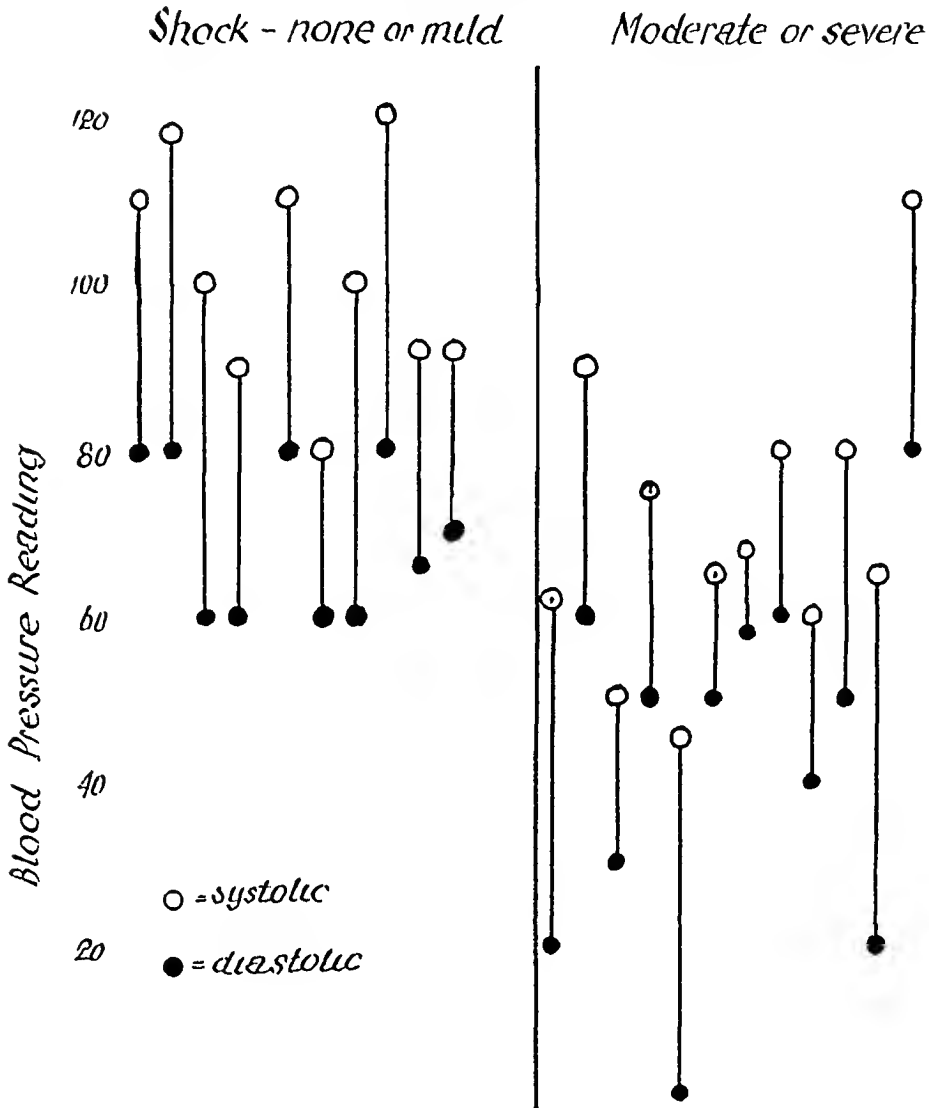


CHART 8—Diagram illustrating the relation of blood pressure readings to the severity of shock in acute blood loss

those individuals in whom we have found an initially relatively normal blood pressure but which was found later to be falling

(d) *Sweating and Temperature of the Extremities*—The sign of cold, clammy extremities has been accepted by many as being almost always present in shock, so we were interested in making observations on how soon this sign appeared and how well its presence or absence correlated with the blood volume estimation. No attempts were made to record temperature accurately, we simply tried to estimate, in a clinical fashion, whether the hands and feet were warm, cool or cold, and whether they were wet with perspiration or dry.

These are, in general, simple clinical tests that can be applied in the field and which, except in the case of blood pressure readings, employ no special apparatus.

BLOOD PRESSURE IN SHOCK

In Charts 8–11 the blood pressure readings for each group have been

placed together, according to the degree of shock manifested on clinical examination. The data on the blood pressure readings in relation to the severity of shock seem to justify the opinion that, no matter what the injury causing the shock, there is a fairly good correlation between the severity of shock and blood pressure readings. By reference to Tables I to IV, the reader will note that in most cases where the blood pressure was found to be relatively low the patient showed clinical signs of severe shock, *i.e.*, cold, wet extremities, *etc.* We have not tried to work out a correlation between

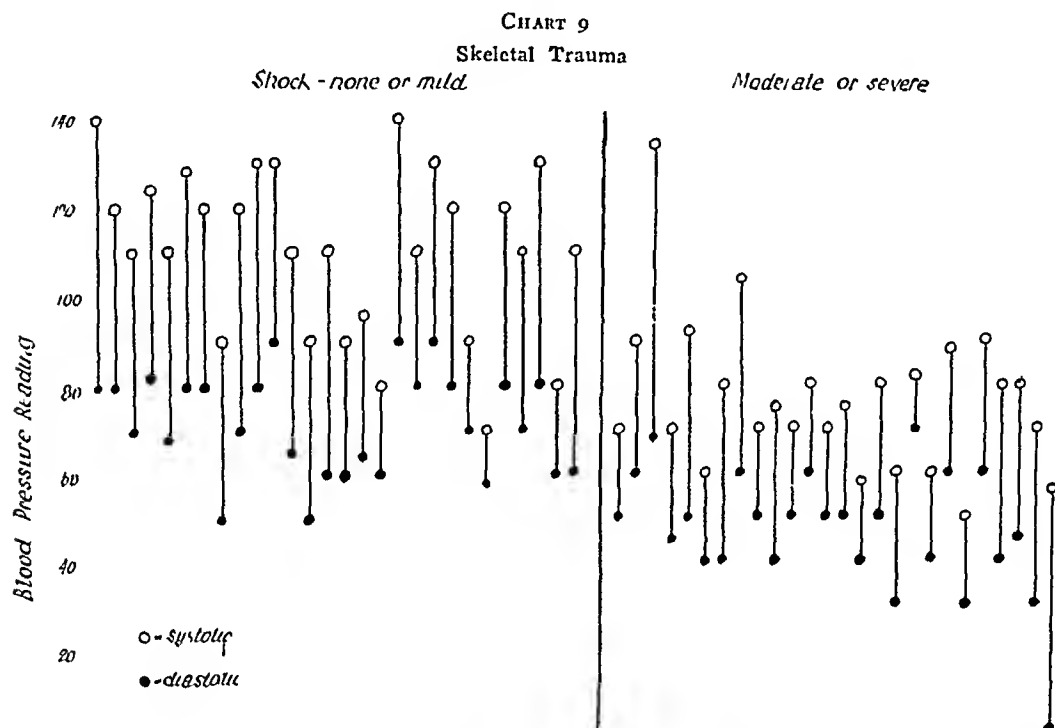


CHART 9.—Diagram illustrating the relation of blood pressure readings to the severity of shock in skeletal trauma

the blood pressure readings and the degree of reduction of blood volume but it is readily evident from a study of the data in Tables I to IV that only rarely does one find a persistent low blood pressure when there has been little or no blood loss. Indeed, in most patients studied in this series there is a good correlation between the degree of reduction of blood volume and blood pressure readings.

Keith² found that cases of wound shock fell into three groups. Group 1. The *compensated* cases in which there was very little blood loss, the blood pressure tending to remain above 100 mm. mercury. In Group 2, the *partially compensated* cases, the blood loss was between 25 per cent and 35 per cent. In these cases the systolic blood pressure was usually between 70 and 80 mm. mercury and a rapid pulse was found. In Group 3, *uncompensated* cases, the blood volume reduction was greater than 35 per cent, and these patients had generally a systolic blood pressure around 60 mm. mercury, with a very rapid heart rate.

The relations between low blood pressure and reduced blood volume,

BLOOD VOLUME IN TRAUMATIC SHOCK

CHART 10
Abdominal Injuries

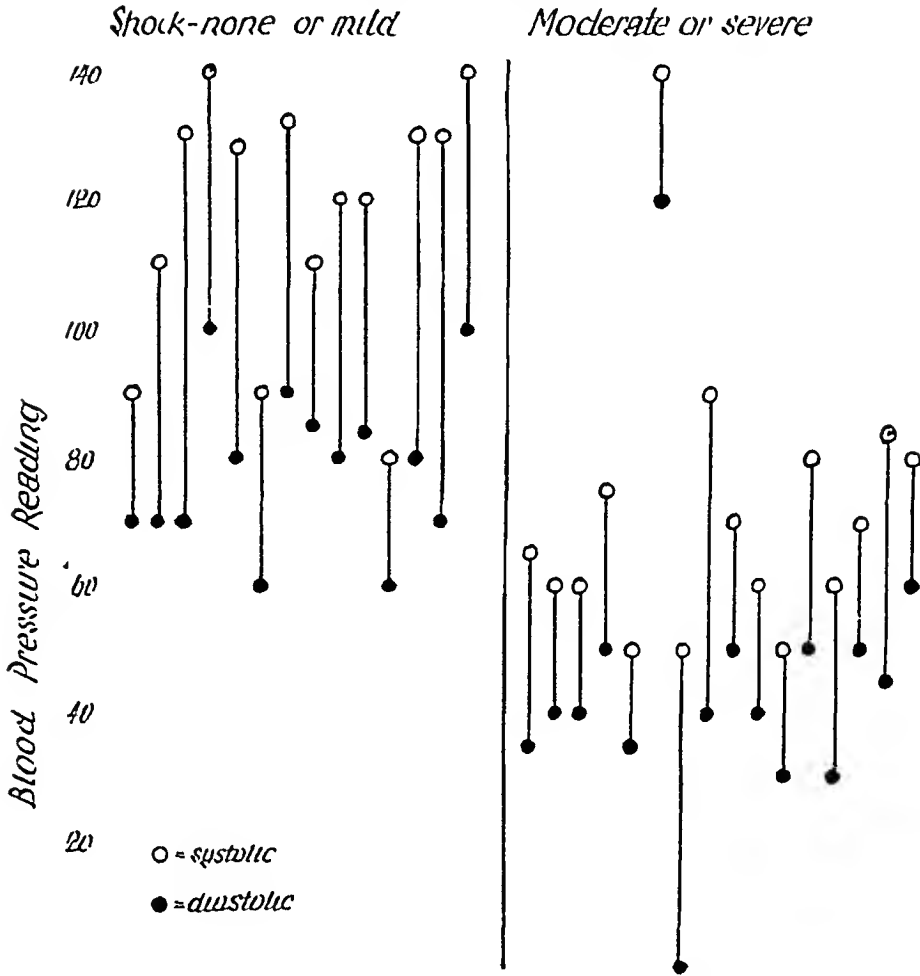


CHART 10—Diagram illustrating the relation of blood pressure readings to the severity of shock in abdominal injuries

reported by Keith, correspond to estimates that we have made with improved blood volume methods. An examination of our data leads us to the conclusion that if a patient has received trauma of the types studied by us and the blood pressure tends to remain below 90 mm systolic, the chances are very great that there has been a considerable blood loss. If, on the other hand, the patient has received severe trauma and, in the Trendelenburg position, maintains a systolic blood pressure above 90 mm mercury it is probable that he has either suffered little blood loss or has rapidly compensated by blood volume restoration for the amount of blood lost.

In this study, therefore, the blood pressure readings have given us a valuable index as to the severity of blood loss in traumatic shock and the degree of reduction of blood volume. This, likewise, was the conclusion of Kewick, *et al*,¹³ who studied 24 cases of secondary traumatic shock during the bombing of London in 1940.

We have not been impressed with the value of the pulse rate as an index of severe traumatic shock. Reference to Tables I to IV will show that there have been many cases where the blood pressure has been found to be at shock levels, the plasma volume estimation indicating a serious deple-

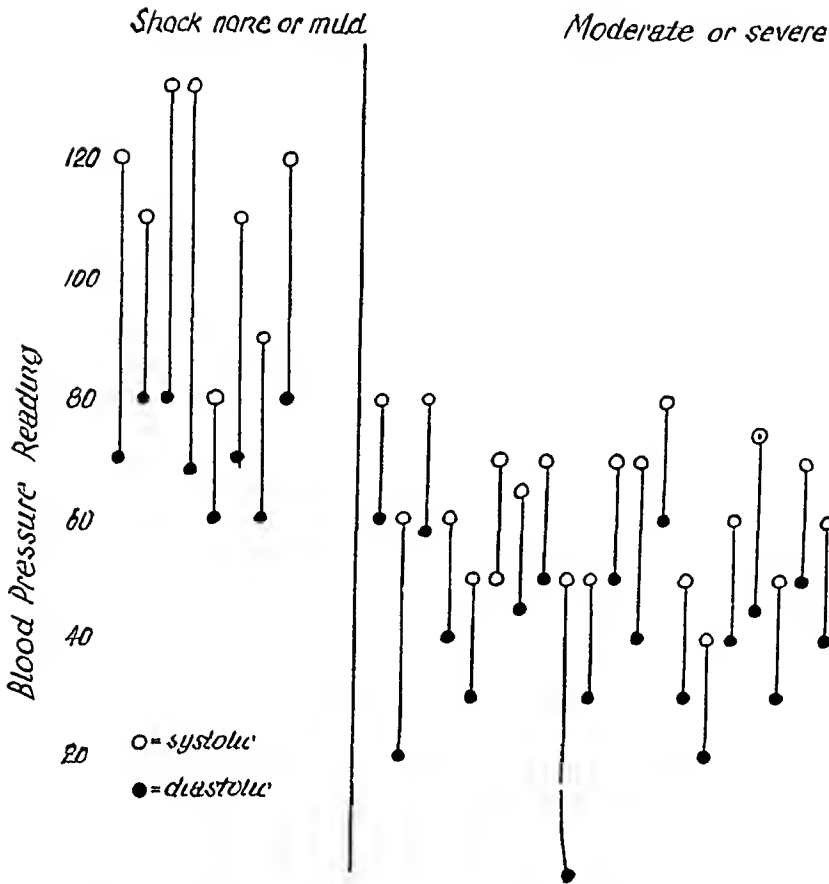
CHART II
Chest Injuries

CHART II—Diagram illustrating the relation of blood pressure readings to the severity of shock in chest injuries

tion of blood volume, while the pulse rate remained more or less within the normal range. We have seen no evidence in our study to indicate that in severe trauma a slow pulse necessarily indicates severe shock. In shock cases seen shortly after the trauma has been received, it is not at all uncommon to find a relatively slow pulse, this is especially true in severe chest injuries.

In individual shock cases an estimation of venous filling time has at times given us a valuable index as to the severity of shock. A study of this point in Tables I to IV indicates that in patients who have received severe trauma but who show little or no signs of shock, the venous filling time is within normal limits, whereas in those patients who have received severe trauma and show evidence of moderate or severe shock, the venous filling time may be considerably prolonged.

Likewise, when venous filling time has been found to be greatly retarded, the temperature of the extremities has been found to be considerably lowered from the normal. It was surprising to us, however, to find that in many patients in severe shock there was relatively little sweating of the extremities, so that we are under the impression that the temperature of the extremities is a far more important indicator of shock than whether or not sweating is present. Indeed, very often one finds in severe shock a cool or cold

extremity which remains dry. Dehydration may have been a factor in our series but we are inclined to doubt this because our patients were seen so soon after the trauma had been received.

PATCHY CYANOSIS

During this study we have had the opportunity to observe six patients who have suffered extreme trauma and who have exhibited the phenomenon that we have termed "patchy cyanosis." The picture may be described briefly as small areas of cyanosis (usually 1 to 2 cm in diameter) scattered closely together on a background of pale, extremely ischemic skin. The phenomenon was seen best on the anterior chest and abdomen. The areas of patchy cyanosis resemble in some respects Bier's spots, except that they are larger and are on a background of ischemic skin. There appeared to be no tendency for these areas of cyanosis to coalesce.

In some regards these areas resemble the patchy ischemia produced in experimental animals by rapid depletion of blood volume, studied so extensively by Rous and Gilding¹⁴

Our reason for calling attention to this sign is that, in our experience, its appearance in patients who have suffered severe trauma has portended in all cases, with the exception of one, an early fatal outcome. In one patient large amounts of blood and plasma were given rapidly, this and other signs of shock then disappeared, with the blood pressure assuming more normal levels. The patient died 48 hours later of an associated cerebral lesion. In the other five patients blood and plasma infusions were started soon after the patients were first seen but death ensued before any considerable increase of blood volume could be effected.

It is our impression that if this sign is seen in shock patients every effort should be made to restore blood volume as rapidly as possible. Even so, the outcome will likely be fatal.

EARLY HEMOCONCENTRATION IN TRAUMATIC SHOCK

Ever since the appearance of Scudder's¹⁵ book on shock, it has been thought by many that the determination of specific gravity of whole blood or plasma would give valuable information in the early diagnosis of shock or impending shock in the patient who has suffered trauma. Indeed, Scudder stated in the final summary of his book (page 195) that the weight of a drop of peripheral blood may serve as a measure of this hemoconcentration, and is of more value than blood pressure determinations, as it heralds, by many hours, its ultimate fall. Moon¹⁶ stated "Experience with this criterion (hemoconcentration) has led me to the conviction that hemoconcentration is the earliest detectable manifestation of shock, as well as the most accurate index of its severity."

We are inclined to believe that determinations of specific gravity of whole blood (or hematocrit determinations) may be of distinct value in following the clinical course of patients with abdominal wounds or other

states in which plasma loss may be profound. It is evident from the analysis of the hematocrit data presented in Chart 7 that the estimation of specific gravity of whole blood would be of little if any aid in the early diagnosis of traumatic shock simply because there is no evidence of hemoconcentration early in traumatic shock. Unfortunately, as this study shows, it is whole blood that is lost in the initial stages of clinical traumatic shock.

From this study of the early clinical signs of shock, we are, therefore, impressed mainly with the value of blood pressure readings. As has been brought out by other writers, the blood pressure reading may be within normal limits when the patient is first seen but if readings are taken every 10 to 15 minutes, in most patients in severe shock (who on blood volume determination will show a considerable decrease in blood volume) it will be found, generally, that the blood pressure readings tend to become lower and lower with the passage of time if treatment of shock is not instituted early. As our group has seen more and more shock patients we have learned that a trained observer can often estimate, with surprising accuracy, the plasma volume simply by taking into account the blood pressure level, the injury, and the state of the patient.

DISCUSSION

It would be unfair to convey the impression that the group of investigators associated with Cannon,¹ and Bayliss,¹⁷ did not appreciate the importance of the depletion of blood volume as a factor in the causation of wound shock. The demonstration by Keith² that the shocked man had a seriously reduced blood volume, whether shock was due primarily to hemorrhage or to a combination of hemorrhage and trauma, seems to have been readily accepted. What is more important from a therapeutic standpoint, restoration of blood volume by transfusion of whole blood or gum acacia solution was early advanced as the most efficient method to treat shock. Keith stated definitely that "recovery from wound shock is associated with an increase in blood volume" (page 16). Nevertheless, the question still puzzled many—what was the cause of the reduction of blood volume in wound shock?" ("However, that the reduction of blood volume is secondary to some still unknown primary cause seems evident" [Keith, page 15])

Although Cannon and Bayliss¹⁸ were convinced of the importance of blood loss as a factor in the production of shock, they entertained strongly the possibility that "the injured muscle would produce metabolites which, on being absorbed into the blood stream, would indicate their presence by a decrease in the blood pressure, with other signs of shock" (page 21).

It is not necessary to go into a long consideration of the many conflicting views regarding the importance of traumatic toxemia as a significant factor in the production of shock, since the evidence has been weighed so carefully in the communications of Parsons and Phemister,¹⁹ and more at length in the excellent treatise of Blalock.²⁰ As Blalock has pointed out, it is un-

fortunate that so many of the experimental studies which have been carried out to test the correctness of the traumatic theory bear little relation to the clinical problem of shock (the implantation of muscle, *etc.*, into the peritoneal cavity, ligation of muscle masses, intravenous infusion of tissue extracts) In his search for the truth concerning traumatic toxemia, the reader may become bewildered by some of the writings on this subject

We wish to emphasize here that we have seen the signs of moderate or severe shock appear in patients who have suffered any of four rather different types of body injury, yet the degree of reduction of circulating blood volume in each of the groups was approximately the same This would indicate to us that in all studies involving an attempt to identify certain toxins as a causative factor in traumatic shock this common factor of blood loss, no matter what the injury, should be properly evaluated

Certain recent studies have indicated the importance of the decrease in cardiac output as an initiating factor in the production of shock We are inclined to the view from an analysis of our clinical shock material to believe that in clinical traumatic shock this follows an early reduction in blood volume, soon after the injury has been received This is more evident in patients who have suffered lacerations of arteries or veins or stab and gunshot wounds of the chest and abdomen Undoubtedly, in many patients there is a primary fall in blood pressure due to neurogenic causes

In experimental studies, as Blalock and others have shown, it is possible to show that the decrease in cardiac output precedes a decrease in blood pressure levels In clinical practice, however, it is our opinion that by the time most patients can be seen after severe trauma has been received, the blood pressure will have fallen to shock levels From then on both cardiac output and blood volume remain low until efforts are made to restore blood volume by plasma or blood infusions If restoration of blood volume and return of cardiac output to fairly normal levels cannot be effected, the patient passes more or less rapidly into generalized anoxia, in which state all the capillary walls become affected When this stage is reached, as clinical experience has shown, blood or plasma infusions are no longer effective

In our attempt to determine the most important factors in the cause of shock, we have not felt the need to consider toxemia as an initiating or contributing factor Likewise, there has been no occasion to consider dehydration or exposure to cold as contributing factors since our patients in general were seen shortly after reception of the trauma

The careful reader cannot fail to be impressed with three factors acting in the production of shock observed in wounded soldiers by Cannon, Bayliss, Robertson, Keith, and others during World War I Their subjects were in the main (1) cold from exposure to wet, cold atmosphere, (2) apparently dehydrated, and (3) a long time getting back to a point "behind the lines" where shock could be treated properly Should an active military campaign be pursued again in climates similar to that found in Flanders, exposure to

cold and rain should not be relegated to the background as a possible important factor in the causation of wound shock

In conclusion, we wish to state that although we regard extreme blood loss at the site of injury as the most important single factor in the causation of traumatic shock, there is no evidence in our observations to exclude the possibility that toxic metabolites absorbed from the zone of injury in severe muscle trauma are not in part responsible for some of the shock picture. This would be especially probable should there be an associated infection in the wound and the patient is seen late. Further, in severe crushing chest injuries where the signs of shock come on rapidly and the patient responds poorly to intravenous infusion of large amounts of blood and plasma, we believe that some cause other than blood loss is responsible for the early fatal outcome in these patients. Indeed, in this group it would appear that there is a rapid and extreme disarrangement of the whole body mechanism. In this group we are inclined to consider seriously a neurogenic factor as being important in the production of shock.

SUMMARY

Using the Gregersen-Gibson method for the estimation of plasma volume in patients who have experienced various types of trauma, it has been found that signs of severe shock do not ordinarily appear unless the blood loss is greater than 15 per cent. The average blood loss in severe traumatic shock has been about 38 per cent, no matter what the nature of the trauma. From analysis of dye disappearance curves, we have found no evidence of increased generalized capillary permeability in traumatic shock. From hematocrit studies, it is evident that what is lost early in traumatic shock in the zone of injury is whole blood, not plasma.

Severe depletion of blood volume appears to be the most important single factor in the causation of traumatic shock.

A decline in blood pressure levels appears to be the most valuable clinical sign in the early diagnosis of clinical shock.

We wish to express our gratitude to our chief, Dr I. A. Bigger, for arranging the facilities that made these clinical studies possible.

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LIPOSARCOMA—THE MALIGNANT TUMOR OF LIPOBLASTS*

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SURELY, one of the most bizarre and fantastic chapters in the story of oncology is furnished by the tumors of fat-forming cells. The strange way in which they grow, their astounding size, equalled by no other tumor, and many other peculiar features and relationships make them of great interest. A good deal of information exists about benign fatty tumors but not nearly as much is known about the malignant ones because of their rarity. For this reason it seems worth while to record the group of 41 cases of liposarcoma which have gradually accumulated in the Laboratory of Surgical Pathology of Columbia University during the past 37 years, and to integrate the information gained from them with what can be gleaned from the publications of others.

As Gideon Wells has so ably pointed out in his fascinating review, adipose tissue has been sadly neglected and fat, which is certainly a substance known to everyone, has been the subject of extraordinarily little scientific investigation. Even its histogenesis is in doubt. Wells discusses this question and the majority of modern observers will agree with him that the older conception of the fat cell as a modified fibroblast (Jacobsen) which has assumed the function of fat storage is no longer tenable. According to Hausberger, Chlopin and Burkhardt the lipoblast is a specialized cell differing from the fibroblast although derived like it from vascular mesenchyme. This difference is emphasized when the lipoblasts of a liposarcoma are grown *in vitro*. Murray and Stout have shown that they can readily be distinguished from fibroblasts. Wells is inclined to accept the work of Wassermann who derives the fat organs from special perivascular mesenchymal cells supposedly related to reticulum and thus makes fat a close relative of lymphoid tissue and the reticulo-endothelial system. Wells supports this by citing the well known interrelationships of fat and lymphoid cells in lymph nodes and thymus and the occasional finding of extramedullary hemopoiesis in fat. But such an assumption does not take into account all of the facts demonstrated by tumors. There are many lipomas, especially the deep intramuscular variety, which are not only associated with blood vessels so that in some areas they look like pure hemangiomas but also with the formation of masses of smooth muscle and there are liposarcomas in which well differentiated bone is a prominent feature (Knox, Josephson and Westberg, Dreyfuss and Lubash, Case 40). Moreover Babès found normoblasts, megakaryocytes and plasma cells in one liposarcoma reported by him. Thus,

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it seems safer to regard the lipoblast as an ordinarily specialized fat-forming mesenchymal cell which on occasion can produce a very wide variety of different and complex tissues

Although lipomas are very common tumors, malignant fat tumors are rare. Moreland and McNamara found only nine liposarcomas among 16,000 tumors of all kinds. In the laboratories of pathology and surgical pathology of the Presbyterian Hospital there are recorded 1454 lipomas and 21 cases of liposarcoma. Since many patients with lipomas never have them removed, the incidence is probably even less frequent.

Perhaps the most sensational feature of fatty tumors is the enormous size which they may attain. Wells says that he has seen a case of liposarcoma which weighed 69 pounds (32 kilos).

Other tremendous liposarcomas, are recorded by McConnell (65 lbs), Salzer (63.8 lbs), Vanderveer (56 lbs), Williams (51 lbs), Harrington (47 lbs), Madelung (38.5 lbs), Waldeyer (30 lbs) and Wechsler (25 lbs). These massive tumors were all either mesenteric or retroperitoneal, with a predilection for the perirenal zone. The record weight and size for a tumor of any kind, so far as I am aware, is held by Delamater's case. This was a fatty tumor which was retroperitoneal and protruded posteriorly outside the left labium majus and buttock so as to form a mass four feet in circumference while the cir-



FIG 1.—Enormous retroperitoneal lipoma weighing at least 179 pounds and possibly 275 pounds. (Reproduced from Delamater's paper in the Cleveland Medical Gazette.)

cumference of the abdomen was seven feet eight inches. When she was weighed about three years before her death she registered 269 pounds, of which it was estimated that 179 pounds were tumor. Supposing that the tumor continued to grow at the same rate of speed after weighing as before, Delamater reckoned that the tumor weighed 275 pounds at death. Even if one rejects this second figure, a tumor weighing 179 pounds dwarfs any of the more recently recorded cases. Delamater's account of this woman's life history from the age of 25, when the abdominal mass was first palpated, until her death in her 36th year is detailed and most interesting, for after a preliminary period of discomfort she became adjusted to the huge mass and, except for its weight which kept her bedridden for the last four years, breathed freely, ate well with good appetite, menstruated regularly, evacuated her bowels easily and remained cheerful. Most extraordinary of all she became pregnant five years before death, although the fetus was born dead (Fig 1).

Adair, Pack and Farnior state that lipomas are more common in females (73 per cent). This sex discrepancy does not apply to liposarcomas, for in

39 liposarcomas in our own series there were 23 males and 16 females, while of 134 cases reported in the literature 71 were males and 63 females. Geographically, they are reported from Europe, Africa and the Americas. Cases from the Asiatic continent have not come to my attention.

The majority develop in the later years of life, 60 per cent of the Columbia University group were past 40 years when the tumor was first noticed, and the mean age was 53 years. Nevertheless, cases are reported in children. Fichman's case, which is somewhat questionable, was congenital, Kretschmer's case was 2 years old, Goeters' $2\frac{3}{4}$ years, Senftleben's 8 years, Sanes and Kenny's 16, while Pack and Anglem mention, without details, 13 cases under age 15. One must be prepared therefore to encounter the tumor at any age.

Trauma seems to play a very minor rôle in the etiology of this tumor. It preceded the appearance of the tumor in the thigh by three months in Jones and McClintock's case, and by a few days in Ackerman and Wheeler's second case, and accelerated the growth of a thigh tumor reported by Adair, Pack and Farrior. In Muller's case trauma to the back occurred one year before the appearance of a liposarcoma in the same locality. So far as our records show it did not play a rôle in any of the Columbia University cases.

There are certain regions of the body where liposarcomas are much more prone to develop than elsewhere. The retroperitoneal area and especially the perirenal portion of it, the mesentery and the omentum are most favored so far as cases previously reported are concerned, for nearly half come from these regions. It would seem, however, that this is due to selective reporting, for in the Columbia University group, which consists of 43 tumors in 41 patients only 7 (16.3 per cent) were in the retroperitoneal, perirenal, omental and mesenteric group. Far more common were the tumors arising in the thigh, popliteal space and gluteal region. There were 15 of these, or 35 per cent of the total. The other regions involved included the trunk 6, head, face and neck 5, inguinal canal and groin 3, leg 3, arm and forearm 3, and mammary gland 1. Other regions reported include intrathoracic (Ackerman and Wheeler, Barbier and Mollard, Chiovenda, Narr and Wells, Perkins and Bowers), meninges (Berger, Caldwell and Zinniger), spermatic cord (Kerschner, Dreyfuss and Lubash, Neal and Jolley, Marshall, Strong), bone (Barnard, Duffy and Stewart, Fender, Rehbock and Hauser, Stewart), vulva (Taussig, Kleeberg), common bile duct (Goeters), doubtful cases in the stomach by Abrams and Turberville, and in the uterus by Springer. Liposarcomas in animals are described by Haagensen and Krehbiel, and by Gavrilov and Silberfeld. Of the soft-part tumors a majority develop deeply from the inter- or intramuscular zones rather than from the subcutaneous fat where a majority of simple lipomas are located. Some tumors have been found closely attached to the sheaths of large blood vessels (Virchow 1857, Huet) but it seems very doubtful that they sprang from these sheaths. Equally open to question is the supposed relationship of lipomas and liposarcomas to nerves, inferred by Virchow 1857, Patel,

Adair, Pack and Farrior, and others Wells discusses this question and wisely leaves it in abeyance The development of lipomas is undoubtedly affected in some fashion by the nervous system but there exists no proof that malignant fatty tumors spring from nerve sheaths themselves

Undoubtedly some liposarcomas develop from preexisting lipomas This is stressed by Schiller, and Katz, and illustrated by our Case 21, where a definite liposarcoma was found completely surrounded by a simple retroperitoneal lipoma above the bladder It is difficult to say how often it occurs because many of the tumors are composed of an intermingling of fully developed fat cells with neoplastic lipoblasts and one has no means of knowing whether or not this state of affairs existed from onset It seems probable, however, that the large majority of malignant lipoblastic tumors are malignant from their beginning

Wells discusses at some length the question of the availability of the lipid in fatty tumors for use as a food in nutritional disturbances He noted that the patient bearing the huge retroperitoneal liposarcoma, reported by Hirsch and himself, was emaciated to the maximum degree and yet the pounds of protein and fat it contained were not available to the patient He quotes other cases of simple lipomas retaining their fat in wasting disease None of the present group of liposarcomas demonstrated this peculiarity, but the Presbyterian Hospital records contain the description of an old woman dying in an extremely emaciated state whose entire small intestine was the seat of multiple submucous lipomas bright yellow in color and made up of solidly packed masses of normal appearing fat cells Wells has not been able to detect any chemical difference between normal and neoplastic fat and cannot explain the phenomenon

There is a bizarre and unexplained fact noted in connection with liposarcoma of the kidney itself Some ten cases have been recorded (4 by Fischer and 1 each by Froug, Harbitz, Hartwig, Lubarsch, McCartney and Wynne, and Judd and Donald) The six cases of Fischer, Froug and Harbitz occurred in individuals suffering from tuberous sclerosis and adenoma sebaceum (Pringle) of the face The records of the Squier Urological Clinic of this Medical Center contain another example of this bizarre association in a young woman who is still alive The classical paper on the subject is by Fischer, who described other types of neoplastic malformations in the kidneys of patients with tuberous sclerosis as well as multiple lipomas and liposarcomas

In addition to their sometimes enormous size, liposarcomas are notable for their variation in growth rate, which occasionally is very rapid and at other times exceedingly slow An excellent example of slow growth is recorded by Martin and Colson Symptoms commenced at 23 years when the woman began to have pains in her thigh At 36 the thigh began to swell At 38 a huge tumor was removed which extended from Scarpa's triangle back to the gluteal fold and forced her to keep the extremity in abduction The mass was excised in two parts from beneath the deep fascia Grossly, it looked

like salmon paste (laitance) and was called either round cell sarcoma or malignant lipoma. Six years later, at age 44, a recurrent mass was removed from beneath the gluteal fold which was soft, diffuent and the color of wet chamois skin. At this time roentgenograms showed rarefactions of the ischium and femur. The next operation was performed 16 years later, when she was age 60. Pieces of the tumor were removed but she died of shock. At autopsy, the tumor surrounded the hip joint, invaded the adjacent bones and passed into the pelvis through the obturator foramen. There is no mention of metastases. This story represents the probable course of a very considerable number of liposarcomas provided it is not interrupted by



FIG. 2—Case 7. Undifferentiated myxoid liposarcoma of thigh. A characteristic example of these bulky tumors.

death or cure. It is of interest that the tumor secondarily invaded bone, because several cases reputed to have been primary in bone formed bulky extra-osseous tumors around relatively small bony lesions, and one wonders if in these cases the bony involvement may not have been secondary (L. Barnard, Fender, Rehbock and Hauser). Indeed, the whole question of the origin of liposarcomas in bone marrow needs further investigation and confirmation from other sources than the one which has sponsored either directly or indirectly almost all of the cases published. The cases originally published by Stewart were challenged by the late W. G. Barnard, and one must acknowledge that they seem different from liposarcomas arising in other tissues.

Some liposarcomas pursue a much more rapid course, as exemplified by several cases in the present series, *e.g.*, Case 7 (Figs. 2 and 3), which attained a size of 24 by 16 cm. in the thigh in six months and caused death by extension and metastasis five months after amputation, Case 9, the total known duration of which was only ten months, and Case 16, which reached a size of 14 x 12 cm. in the buttock in six months and resulted in death with intra-abdominal and lung involvement in another six months. Between these extremes there are all grades of variation, but with the greater number exhibiting slower growth and with a relatively small number spreading by metastasis. Before the question of metastasis can be debated, the extremely interesting subject of the multiplicity of tumors must be elaborated for the two inevitably become confused one with the other.

It is well known that lipomas are often multiple, occasionally one or

more of these fatty tumors develop in the body and, succeeding them, many other tumors appear as if they were metastases. Lubarsch's case is representative of one type. There was a large multinodular fibrous and fatty tumor in the left perirenal region with many smaller similar foci in the kidney itself, retroperitoneal region, suprarenal gland, liver, heart, subpleura, left lung, periaortic and retro-esophageal areas, spinal vertebrae and both femora. In spite of the benign appearance he believed these small foci were metastases. Siegmund described a very similar case except that the secondary nodules



FIG 3—Case 7. The tumor lay deep to the sartorius, semimembranosus and vastus medialis muscles which have been dissected away to expose it. At the right the cut surface of the tumor is shown.

appeared like liposarcomas. He believed that both his own and Lubarsch's cases were examples of multiple tumors and not metastasis formation. Somewhat comparable cases have been recorded by Goormaghtigh, *et al*, who favor the metastasis hypothesis and by Martland, Gold, and Sternberg, all of whom preferred to believe that the tumors were independent. Somewhat more frequent are instances in which a few more or less widely separated liposarcomas appear simultaneously or successively, and one must decide whether they are independent or represent metastases. An excellent example is Case 15 in the present series, previously reported by Murray and Stout. The first tumor appeared in the antecubital fossa and two and one-half years later a second tumor developed higher up in the arm. In Case 32 there were three entirely separate liposarcomas in the thigh, the popliteal space and in the pelvic retroperitoneal space. In Case 7, following amputation for a thigh liposarcoma, the patient died with tumors in the pelvis, back, gluteal region and cerebrum. The cerebral tumor must have been a metastasis but

should one accept the other three nodules as extensions, metastases or separate tumors? Similar problems arise with regard to cases reported by Hosemann and Lang, Josephson and Westberg, and Narr and Wells. It seems to the writer that in the majority of the above quoted cases one is dealing probably with multiple independent tumors. The question is of more than academic importance for it has some bearing on the choice of treatment.

The preceding paragraph indicates that there are some cases in which apparent metastases may only be multiple tumors. It should not be interpreted as meaning that metastases never occur in cases of liposarcoma, for most certainly they do. In addition to one example each by the five reporters of bone liposarcomas, unquestionable metastases are recorded by Daniel and Babes, Geschickter, Gricouroff, Harbitz, Jaffé, Lepoutre, Lifvendahl, Menne and Birge, Moreland and McNamara (2 cases), Nieuhuis, Seids and McGinnis (2 cases), Stich, Taussig, Vincent and Sennellart, Virchow (1857 and 1865), and Waldeyer. To these may be added Cases 3, 6, 7, 9, 14, 16, 26, and 34. From the data at hand, it is impossible to determine the relative frequency of metastases because there exists no series of consecutive cases followed over a long enough period to be of statistical significance. The impression one gains from the literature is that metastases are less common than with other types of sarcoma since among 134 cases there are only 24 with metastases, and if one subtracts the eight bone cases from the total then there are only 19 among 126. If one takes the Presbyterian Hospital cases, most of which have been followed, and excludes the last four which have occurred within the last two years, there remain 17 cases of which six have shown metastases. If Cases 2, 4 and 11 are also subtracted because they represent examples of the well differentiated form of liposarcoma, often called myxolipoma or some comparable name, there are then six metastatic cases among a group of 14, or 40 per cent. This figure is probably somewhere near the truth. In 60 per cent of cases metastases lodge in the lungs or pleurae, in 25 per cent in the liver, after which come bone marrow and central nervous system, with isolated examples of involvement of other scattered parts. In no single acceptable case were there widespread metastases—a further argument against the acceptance of the cases of Lubarsch and Siegmund as ones of extensive metastasis rather than multiple tumors.

The gross characteristics of liposarcomas are quite varied but in general they form large bulky, nodular, masses of apparently encapsulated tissue which is always firmer than the adipose tissue of simple lipomas and runs a gamut of colors from orange to pale cream often with an admixture of reds caused by areas of increased vascularity or hemorrhage (Fig 3). Somewhat more than half of them are slimy and mucoid (Fig 4). These tumors not infrequently have areas of normal yellow fat interspersed among the sarcomatous masses. In a few tumors there are dense fibrous areas. Occasionally degeneration cysts may form but this is exceptional and even the colossal tumors usually remain solid throughout in spite of extensive areas of degeneration. Secondary or local multiple nodules are probably quite frequent and account

for the many times which local recurrences manifest themselves after attempted excision

The microscopic features of liposarcomas are even more varied than the gross and unfortunately have given rise to a great variety of names which make for confusion and misconception Ewing (1935) gives us a basic separation of liposarcomas into two main types One, the myxoliposarcoma, which is vascular myxoid and lipoblastic, the other, the granular cell lipoblastoma composed of cells resembling the foamy lipoblasts of brown fat With this recognition of two forms of lipoblasts, all who have had any degree



FIG. 4—Case 12 Undifferentiated myxoid liposarcoma after its removal from within the gastrocnemius muscle The highlights of the cut surface at the right represent slimy mucoid material

of experience with these tumors will agree but will demand further elucidation How, for instance, can one distinguish between what is so frequently called myxolipoma, fibromyxolipoma or some similar name and Ewing's myxoliposarcoma? The answer to this query is that one cannot, because, as Gricoureff has pointed out, the "*lipome embryonnaire*" or myxoid lipoma can behave like a malignant tumor by recurring and metastasizing He places them between simple lipomas and atypical liposarcomas Mucicarmine will stain the intercellular substance but never intracellular vacuoles which contain lipoid He points out that these tumors may have areas resembling fibrosarcomas poor in collagen as well as myxoid areas Jaffé also recognizes

these three different variants which he called respectively lipoblastomas, lipoma pseudomyxomatodes and liposarcoma but he was apparently not aware that the first tumor form might recur after excision and the second both recur and metastasize. Moulouguet and Pollosson also have three divisions of lipoblastic sarcoma which they call respectively malignant lipoma, lipoblastic myxoid sarcoma and lipo- and fibroblastic sarcoma.

This attempt to divide the malignant fat-forming tumors into three separate and distinct groups is doomed to failure, however, because when one has a relatively large group to study, such as the 41 cases in the present collection, one finds that all of the cases are not pure types but that some of them are

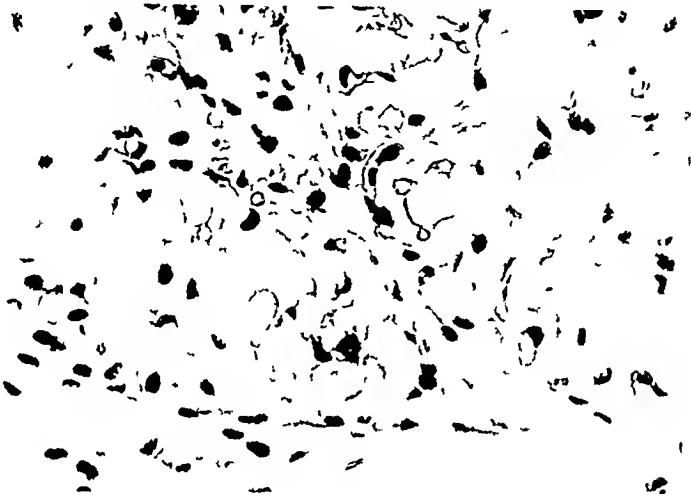


FIG 5—Embryonal fat from the subcutaneous layer of a supernumerary finger removed a few days after birth

mixed. This should have been anticipated, since it has already been pointed out by Schiller, and others, that a benign lipoma can change its characteristics and become a malignant tumor, and if one such mutation is possible, theoretically any other change is possible. As a matter of fact, all combinations of the above described histologic types are found in different tumors of this series. For example, both myxoid and round cell (adenoid) areas are found in different parts of Cases 5, 8, 17, 22, 24, 28, and 29, combinations of myxoid and fibrosarcomatous areas in Case 25, myxoid, round cell and fibrosarcoma-like areas in Case 14, and areas of osseous and cartilaginous metaplasia in an otherwise myxoid tumor in Case 40. The fact that both myxoid and adenoid or round cell developments may be found in the same tumor seems to be an observation of some importance. It indicates that there are probably not two separate and distinct ancestral lipoblasts, one of which forms ordinary adipose tissue and the other brown fat, but that the same ancestral cell in the primitive mesenchyme is capable of forming either or both—certainly, Figures 11 and 12 show that the two types can be so juxtaposed in the same tumor that one can hardly credit that they were formed by two different cell prototypes. If this is true it should lead

LIPOSARCOMA

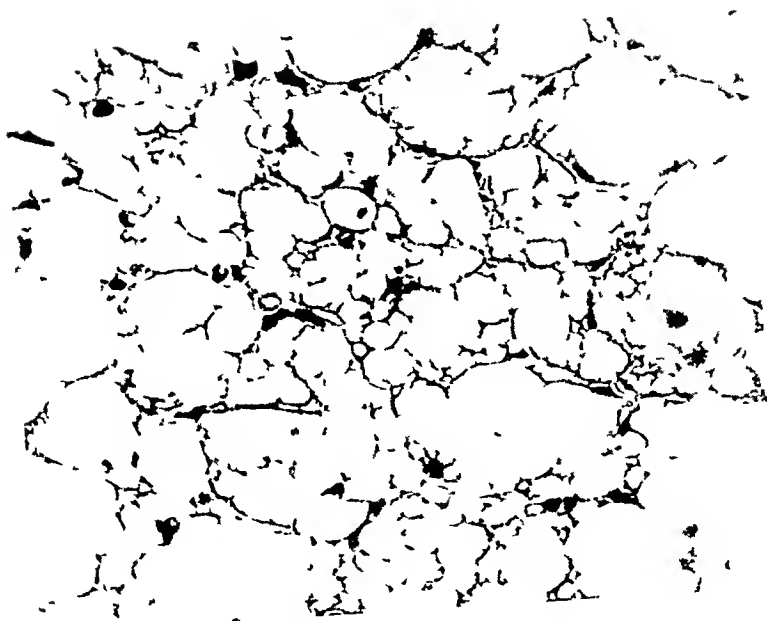


FIG 6—Brown fat from the deep fatty tissues of the lateral neck region of a male, age 41

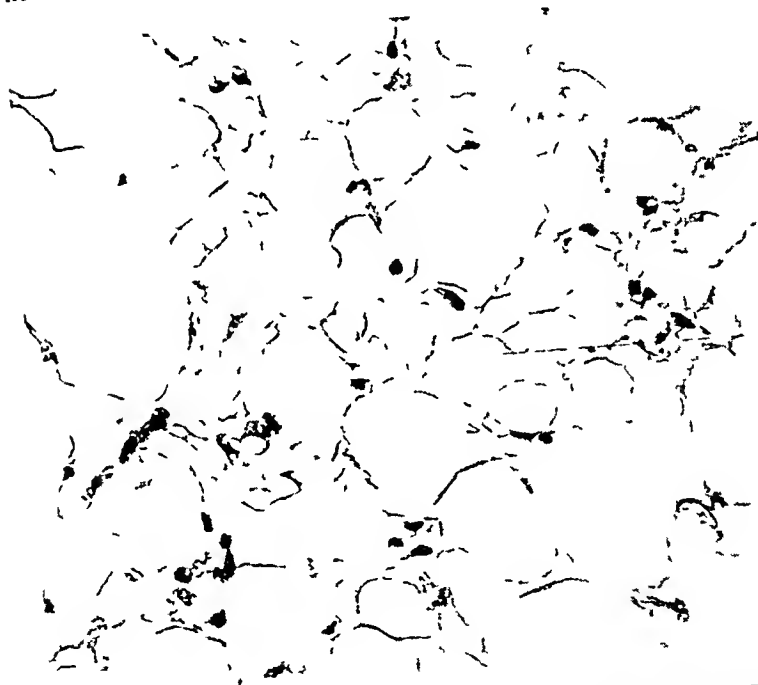


FIG 7—Case 19 Differentiated myxoid liposarcoma The photomicrograph shows embryonal lipoblastic tissue, resembling the embryonal fat shown in Figure 5, mixed with adult fat cells

us to look upon the liposarcomas not as a group of separate and distinct tumor types worthy of bearing separate names but as a single group capable of manifesting different degrees of differentiation which can be indicated by descriptive adjectives. Since this group represents the malignant form of the fat-forming tumor it is quite properly called liposarcoma. With this conception in mind, liposarcomas may be subdivided as follows

I *Well Differentiated Myxoid Type* This resembles the usual type of embryonal fat (Figs 5 and 7). It consists of adult fat cells, embryonal stellate- or spindle-shaped fat cells containing droplets of a material which can be

stained with scharlach R or sudan III, and usually a rather rich network of capillaries. The whole mass is bound together by a loose meshwork of connective tissue which is generally, but not always, slimy and myxoid. Sometimes this slimy material can be tinted with mucicarmine and sometimes not. This characteristic picture is occasionally varied by the presence of more or less dense fibroblastic tissue with well developed collagen and reticulin fibers. The lipoblasts whether stellate- or spindle-shaped are rather small, regularly formed and, although such tumors may be enormous, it is almost impossible to detect any mitoses. It is questionable whether such tumors ever metastasize while they remain in this state of good differentiation. Cases 2, 4, 11, 19, 31, 36, 37 and 41 are examples.

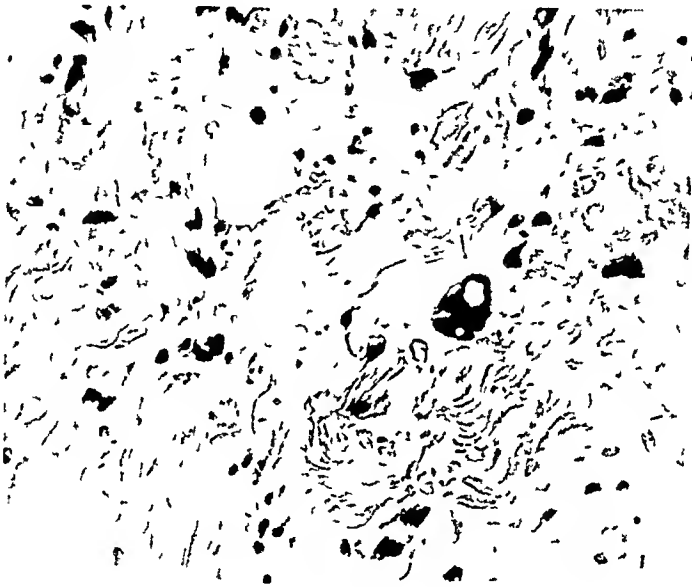


FIG. 8—Case 10. Undifferentiated myxoid liposarcoma. The lipoblasts are bizarre with hyperchromatic nuclei. The stroma of this tumor is quite fibrous.

2 Poorly Differentiated Myxoid Type This group resembles the first group, with the important difference that the lipoblasts are bizarre and often monstrous. They grow to a large size with astonishingly variable nuclear formations and the misshapen nuclei are often hyperchromatic or pyknotic (Figs 8 and 9). As noted by Murray and Stout, such cells are usually degeneration forms and incapable of reproduction *in vitro*. The bizarre lipoblasts often dominate the picture and the amount of lipid produced is correspondingly less. Signet-ring forms are occasionally seen. Completely differentiated adipose tissue is less or entirely absent and the number and arrangement of blood vessels so variable as to be no longer significant. Fibrosarcomatous areas are sometimes produced (Fig 14). This poorly differentiated type is definitely malignant, difficult to eradicate, and may metastasize. It is represented in this series by Cases 1, 6, 7, 9, 10, 12, 13, 15, 18, 19, 20, 21, 23, 26, 30, 32, 33, 34, 35, and 40.

3 Round Cell or Adenoid Type The characteristic lipoblast of this tumor type is rounded with centrally placed nucleus and voluminous foamy cytoplasm,

the vacuoles of which are filled with lipoid. The cells are massed together in close approximation with only a delicate fibrous framework and an inconspicuous blood supply (Figs 10, 11, and 12). In many such tumors the cells may reach an enormous size. Jaffé measured them as large as 120 microns and the cell illustrated in Figure 13 is 126 microns in length. The hyperchromatic pyknotic nuclear material indented by the vacuoles suggests that these are degeneration forms. These tumors are not myxoid. Like the tumors of the second group they are difficult to eradicate and may metastasize. Cases 3, 16, 27, 38 and 39 are examples of this group.

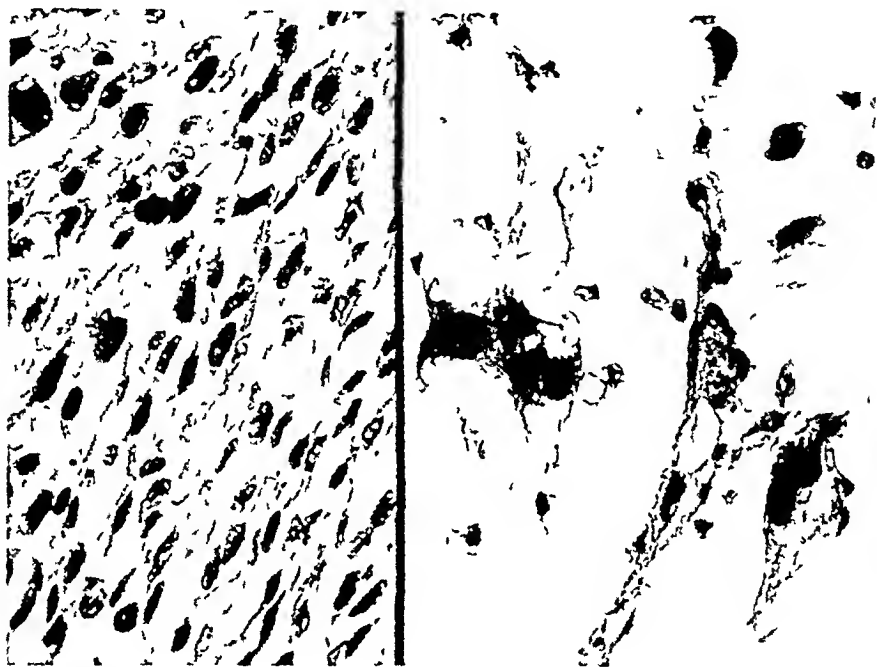


FIG 9—Case 35. Undifferentiated myoid liposarcoma. At the right are bizarre lipoblasts partly filled with vacuoles in a mucoid stroma. At the left, the lipoblasts are elongated, probably because there is little intercellular material and they tend to be compressed.

4 *Mixed Group*. These are the tumors composed of two or more elements of the preceding groups. They, too, are definitely malignant (Figs 10, 11, 12, 14). Representatives are Cases 5, 8, 14, 17, 22, 24, 28 and 29.

Diagnosis of any tumor should be made with accuracy before it is treated. Liposarcomas can be suspected clinically if they have reached a very large size and with some degree of certainty at exploration if in addition the tumor is both yellow and slimy. But the only proper procedure is biopsy before treatment, confirmed by immediate frozen section if possible, if not by paraffin section. Progress in the treatment of soft part tumors will never be attained if this is not made a routine procedure instead of the all too common method of excising the whole tumor first and secondarily trying to carry out some further and more radical procedure if the growth proves to be malignant. Liposarcomas have such distinctive histology that the only tumor with which they may easily be confused is the myxoma. The myxoma has no lipoblasts and no fat is formed. The differentiation between the two is worth while because the myxoma, while it may continue to grow if not completely excised, never metastasizes, so far as this writer is aware.

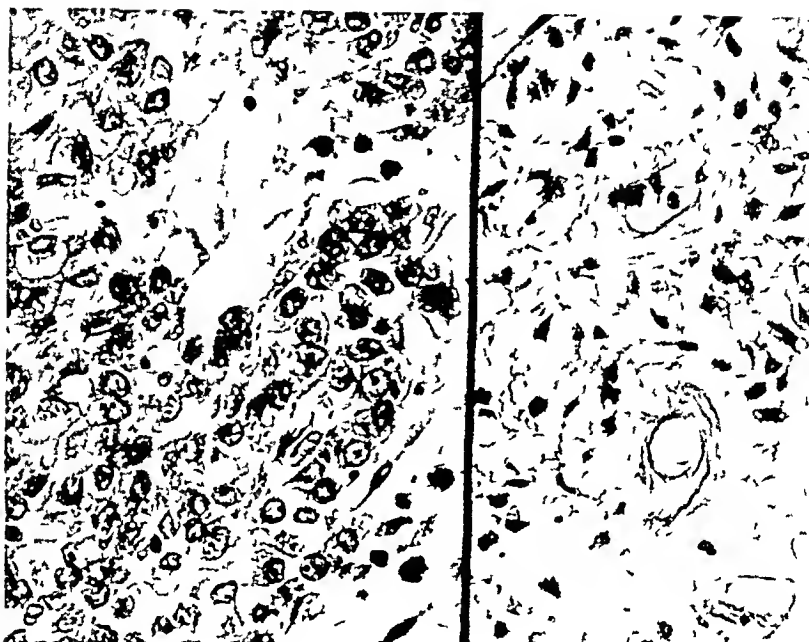


FIG 10—Case 24 Mixed myxoid and round cell liposarcoma At the right a myxoid area is shown resembling the embryonal fat shown in Figure 5 At the left is the junction between a myxoid and round cell area The rounded lipoblasts are honeycombed with tiny lipid vacuoles

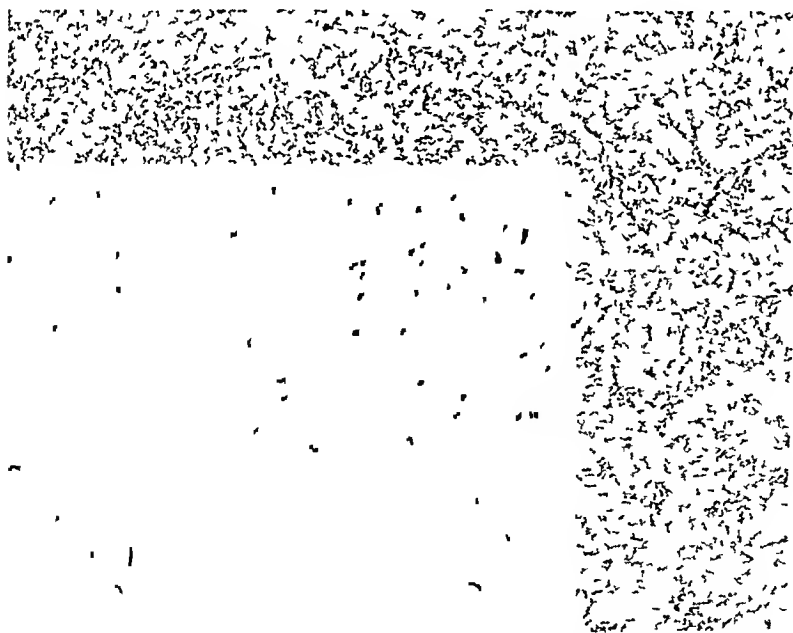


FIG 11—Case 8 Mixed myxoid and round cell liposarcoma At the left is shown the solid mass of rounded lipoblasts At the right is the loose textured vascular myxoid portion of the tumor

Treatment of liposarcomas is primarily surgical but it should be pointed out that some liposarcomas have proved to be definitely radiosensitive, and for this reason radiotherapy as a mode of treatment must not be neglected. Ewing (1935) has recommended that it be used before any operation. In Cases 12 and 15 of this series it was used on relatively small recurrent nodules with success lasting seven years and five months in the former and two and one-half years in the latter. Radiotherapy was used in six other Presbyterian Hospital cases either without any benefit or with only temporary effect. It should be noted that the good results were obtained with rather small recurrent masses in easily accessible situations while the failures were

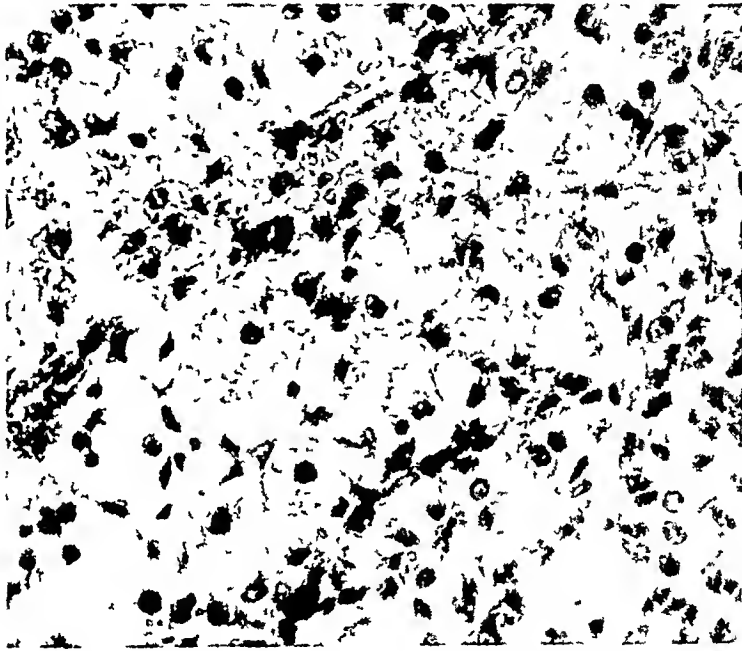


FIG 12—Case 8 Details from the junction of the two cell types shown in Figure 11. The rounded, finely vacuolated lipoblasts are intermingled with the stellate and elongated cells of the myxoid area.

in larger and usually deeper tumors. The details are recorded elsewhere in this paper. Reports from other clinics are discouraging. It was used postoperatively to prevent or because of recurrences by Moreland and McNamara in two cases, by De Renzi, Selman, and Seids and McGinnis in one case each, with complete failure. Another case treated by Seids and McGinnis postoperatively was without recurrence at the end of one year, too short a time to be significant. Siegmund treated some of the many tumors in his case with roentgenotherapy and reported partial and temporary regression. In spite of this, one should be encouraged to believe that since some success has been obtained at the Memorial Hospital and in this institution, this is a form of treatment which should not be abandoned.

If a tumor is a well differentiated myxoid liposarcoma, one does not need to be as radical as for the other three groups, because the worst that may be expected is local recurrence. Nevertheless, it will pay to treat even these tumors with respect and remove the entire capsule and the tissue

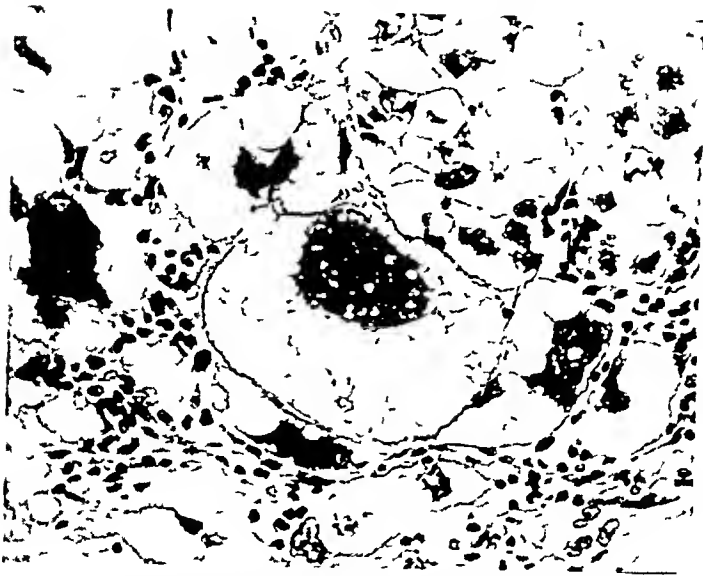


FIG 13—Case 27 Detail of a round cell liposarcoma showing giant lipoblasts. The large cell in the center is 126 microns in length. It is probable that these huge cells are degenerate and incapable of reproduction.

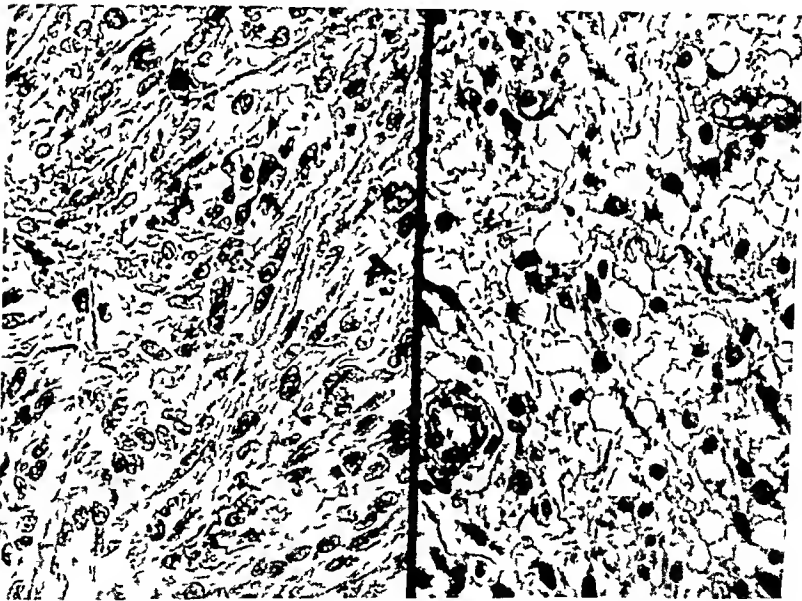


FIG 14—Case 14 Mixed myxoid and round cell liposarcoma. At the right a myxoid area with intermingled round cell lipoblasts. At the left an area where the cells simulated the appearance and arrangement of a fibrosarcoma.

immediately outside of it because one can never be absolutely sure that the entire tumor is well differentiated, or that a recurrence may not be less well differentiated and more malignant. The ease with which a second nodule may be overlooked is illustrated by Case 19. An apparently encapsulated tumor attached to the deep fascia was enucleated from the thigh with the diagnosis of lipoma. When the microscope showed that it was a liposarcoma, the whole area was reexcised. In the gross specimen, a second deeper entirely unsuspected nodule of similar type was discovered.

LIPOSARCOMA

TABLE I

RECORD OF CASES*
PRESBYTERIAN AND ALLIED HOSPITAL CASES

Case No	Sex	Age	Site	Duration Before Diag Mos	Size—Cm	Type	Treatment	Result
1	F	65	Lumbar	?	?	Myxoid (undiff)	Excision	?
2	F	43	Canal of Nuck	5	12 x 7 x 2	Myxoid (diff)	Excision	No recur 22¼ years
3	M	33	Retroperitoneal (psoas-iliacus musc)	3	21 x 17 +	Round cell	Partial excision Radiotherapy	Died 15+ months Lung and liver metastases
4	M	38	Back of neck	12	7 x 6	Myxoid (diff)	Excision	No recur 17½ years
5	F	29	Back	120	4 x 2 7	Myxoid (undiff) and round cell	Excision	No recur Died 45 mos myocarditis
6	F	60	Omentum	0 75	"very large"	Myxoid (undiff)	Biopsy	Died postop Metas in liver and pleurae
7	M	59	Thigh	6	21 x 16	Myxoid (undiff)	Biopsy Amputation	Died 5 mos Metas to cerebrum Tumors in pelvis, back & gluteal regions
8	F	55	Thigh	180	21 x 15 x 9	Myxoid (undiff) and round cell	Excision Radiotherapy	Recurred Died 42 mos postop
9	M	40	Scapular reg	3	15 x 13	Myxoid (undiff)	Excision Biopsy recur Radiotherapy	Died hemorrhage 7 mos postop Metas to lungs & extension to axilla
10	M	66	Cheek	24	3 x 2 x 1	Myxoid (undiff)	Excision	No recur 15 mos postop died "heart disease"
11	M (colored)	37	Temporal reg	96	8 x 8 x 4	Myxoid (diff)	Excision	6 years 3 mos—no recurrence
12	F	59	Leg (gastrocn mus)	7	12 5 x 6	Myxoid (undiff)	Excision Radiotherapy of reputed recur	Reputed local recur at 15 mos 8 yrs, 8 mos after op no definite disease
13	F	57	Retroperitoneal	132	42 x 22 x 18 (wt 28 lbs)	Myxoid (undiff)	Biopsy	Died postop No metastases
14	M	32	Thigh	4	15 x 11	Myxoid (undiff) with areas like fibrosarcoma and round cell	Excision Reexcision Radiotherapy	Died 67 mos after 1st op with recur and lung metastases
15	M (colored)	64	Forearm	5	20 x 8 x 6	Myxoid (undiff)	Excision Excision of 2nd tumor Radiotherapy of re-cur	2nd tumor in arm and recur in forearm after 30 mos No evidence of tumor 60 mos after 1st op
16	M	74	Gluteal	6	14 x 12	Round cell	Biopsy Radiotherapy	Died 6 mos—lung met and intra-abdominal tumor
17	F	52	Thigh	3 5	16 x 16	Myxoid (undiff) and round cell	Biopsy	Died 1 mo—hemorrhage
18	F	75	Perirenal	12+	15 x 15	Myxoid (undiff)	Excision Nephrectomy	Died 3 mos
19	F	46	Thigh	3	4 x 3 & 2 7 x 1 5	Myxoid (diff)	Excision in 2 stages	Recovered
20	M	49	Thigh (intra-muscular)	24	27 x 18 x 11 (wt 7 5 lbs)	Myxoid (undiff)	Biopsy Excision	Recovered
21	M	86	Retroperitoneal (above bladder)	7	8 x 8	Myxoid (undiff) (within larger lipoma)	Excision	Recovered

TABLE I—(Continued)
CASES FROM OTHER SOURCES

Case No	Sex	Age	Site	Duration Before Diag Mos	Size—Cm	Type	Treatment	Result
22	F	Adult	Arm	?	4 x 3 x 2	Myxoid (undiff) and round cell	Excision	?
23	F	28	Thigh	?	Unknown	Myxoid (undiff)	Excision	Local recur after 4 yrs
24	M	50±	Popliteal space	6	16 x 15	Myxoid (undiff) and round cell	Excision	No recur after 4 years
25	M	?	Forearm	?	Unknown	Myxoid (undiff) with areas like fibrosarcoma	Excision	?
26	M	60	Popliteal space	24	18 x 12 x 8	Myxoid (undiff)	Excision Radiotherapy	Died with met after 3 yrs 2 mos
27	M	62	Inguinal	2	10 x 10±	Round cell	Partial excis	?
28	F	62	Back	3	20 x 13 x 5	Myxoid (undiff) and round cell	Excision	?
29	M	55	Popliteal space	2	12.5 x 10 x 10	Myxoid (undiff) and round cell	Excision	?
30	?	?	Leg	?	?	Myxoid (undiff)	Excision	?
31	M	67	Scrotum canal & pelvic retroperitoneum	48±	Large	Myxoid (diff)	Excision	?
32	M	54	(1) Thigh (2) Pop space (3) Pelvic retroperitoneum	144	(Retroperit Weighed 1-2 kilos)	Myxoid (undiff)	Excision of all 3	?
33	?	?	Leg	?	8.5 x 8	Myxoid (undiff)	Amputation	?
34	F	58	Popliteal space	12	16 x 9	Myxoid (undiff)	Biopsy Excision	Died with metastases
35	M	50	Axilla	0.5	12 x 12	Myxoid (undiff)	Excision	?
36	M	Adult	Cheek	?	3.2 x 2 x 1.8	Myxoid (diff)	Excision	?
37	M	50±	Lumbar	?	?	Myxoid (diff)	Excision	?
38	F	18	Gluteal	6±	8 x 7 x 6	Round cell	Excision Radiotherapy	9 years no recurrence
39	M	57	Infraclavicular (also on mammary gland)	?	?	Round cell	Excised	?
40	M	68	Gluteal (intra-muscular)	2	19 x 13 x 5.5	Myxoid (undiff) (with bone & cartilage metaplasia)	Excised	?
41	F	50	Orbit	1	?	Myxoid (diff)	Excised	?

*These cases have the following origins: Case 22 from Vanderbilt Clinic, New York, Dr. P. R. Turnure, Case 23 from Roosevelt Hospital, New York, Dr. W. C. White, Cases 24 and 25 from Lincoln Hospital, New York, Dr. Chester R. Brown, Cases 26, 28, 30, 31, 35, 36 from the Nix Hospital Laboratory, San Antonio, Texas, Dr. A. O. Severance, Case 27 from the New York Postgraduate Hospital, Dr. M. N. Richter, Case 29 from the Hospital for Ruptured and Crippled, New York, Dr. H. Pheasant, Case 32 from Ellis Fischel State Cancer Hospital, Columbia, Mo., Dr. L. V. Ackerman, Case 34 from Cornwall Bridge, Connecticut, Dr. W. C. Clarke, Cases 37 and 41 from the Hospital of the University of Pennsylvania, Dr. R. C. Horn, Case 38 from the Mather Hospital, Port Jefferson, L. I., Dr. Ethel Trygstad, Case 39 from Bellevue Hospital, New York, Dr. W. G. von Glahn, Case 40 from Vassar Bros. Hospital, Poughkeepsie, N. Y., Dr. Elizabeth Heath.

DETAILS OF CASES TREATED WITH RADIOTHERAPY

Case 3—One month after operation six radiotherapy treatments were given in the course of two weeks. Factors unknown. No effect.

Case 8—Immediately after operation eight treatments were given during a period of three and one-half months through anterior and posterior 15 x 20 cm fields to thigh and hip, totalling 2300 r with the following factors: 200 kv, 50 cm skin distance, 8 ma, 1.86 mm cu + 1 mm al. Sixteen months later after the tumor had reappeared, 16 more treatments were given to 20 x 25 cm anterior and posterior thigh and hip fields, totalling 4800 r. The factors were: 195 kv, 50 cm skin distance, 8 ma, 1.86 mm cu + 1 mm al. Eight years before operation the original tumor had been treated elsewhere with roentgenotherapy without effect. The treatment of the recurrence had no effect.

Case 9—The treatment given was to a large rapidly growing local recurrence and axillary extension. 2790 r was first given to the recurrent mass. Factors: 200 kv, 30 ma, 50 cm skin distance, filter 1/2 mm silver and 1 mm of aluminum. This caused some shrinkage. Three months later, using the same factors, 1860 r were given through anterior and posterior fields to the axilla. This was supplemented after 3 months with 4900 mg hrs of radium in 3.5 cm radium needles. The effect was slight and probably did not retard the fatal termination.

Case 12—When a 2.5 x 2 cm mass appeared in the scar 15 months after excision this was assumed to be a recurrence. This was treated through two 8 x 10 cm fields, a total of 6000 r in 40 days was given. Factors: 200 kv, 25 ma, skin distance 50 cm, filter 2 mm cu + 1.25 mm al. This caused complete disappearance of the mass and it has not reappeared in the succeeding 7 years and 5 months.

Case 14—Roentgenotherapy was begun after a recurrent tumor mass was excised with resection of the sciatic nerve from the posterior thigh. During a period of 5 months through two 10 x 15 cm and one 8 x 12 cm fields a total of 9000 r was given. Factors: 190 kv, 8 ma, 50 cm skin distance, 1.31 mm cu + 1 mm al filter. One year after the termination of the first course there was no local tumor in the thigh but a mass could be felt deep in the iliac fossa. A second course was begun using three 15 x 15 cm fields in the thigh and hip regions. It was continued for 3 months, and a total of 9000 r was given with the following factors: 200 kv, 25 ma, 50 cm skin distance, filter 1.05 mm cu + 1.25 mm al. This did not prevent the tumor from persisting and slowly filling the pelvis. Two months after the termination of the second course a little more irradiation was given to the abdomen and pelvis, totalling 975 r. All of this failed to check the progress of the disease to a fatal termination.

Case 15—Details of radiotherapy given in paper by Murray and Stout.

Case 16—The roentgenotherapy given in this case represents treatment of the tumor begun 3 days after biopsy. Three 10 x 15 cm fields were used and a total of 7000 r given in a period of 40 days. The factors were: 200 kv, 25 ma, skin distance 50 cm, filter 1 mm cu + 1 mm al. The patient left the city before any more treatment could be given. It did not check the progressive growth of the tumor and the rapid fatal termination.

Case 20—This represents postoperative prophylactic radiotherapy. Two 8 x 20 cm and two 10 x 20 cm fields were used and a total of 8000 r given in a period of 54 days. The factors were: 200 kv, 25 ma, 50 cm skin distance, filter 1 mm al + 1 mm cu. The case is too recent to have any significance.

The principle of treatment for all other liposarcomas should be radical surgery, if a cure is to be attempted. Failures are bound to occur, however, in some cases, such as the retroperitoneal tumors, because their situation makes complete removal impossible, and in others because there may be undiscovered multiple tumors. In many cases this may not result in immediate death even with recurrence, because so many of these tumors progress slowly and fail to metastasize. It would seem not worth while to attempt very extensive and shocking operations in the very old and infirm because the risk of operative death may be greater than the untoward results which may follow more conservative treatment of the tumor. One cannot establish rules to govern the treatment of every individual case, because the factors are so many and so varied. One can only keep in mind the possibilities when treatment is planned.

SUMMARY

A group of 41 cases of liposarcoma has been studied in connection with 134 previously reported cases. These tumors tend to form very large bulky masses, with a predilection for the thigh and extraperitoneal tissues but with occasional appearance in many other regions as well. They exhibit great variations in growth speed, they are sometimes multiple and the more malignant forms metastasize usually either to the lungs or liver.

Grossly, these tumors are frequently mottled with yellow because of their lipid content and are often slimy from the formation of mucoid material. Microscopically, they can be divided into one well differentiated, less malignant group, which simulates the appearance of ordinary embryonal fat and three other poorly differentiated more malignant groups resembling respectively atypical ordinary embryonal fat, atypical brown fat with the formation of rounded lipoblasts, and finally a group showing both of these elements in combination. Probably as a result of metaplasia these tumors can on occasion form other tissues such as reticulin and bone. This versatility suggests that there are probably not separate embryonal stem cells for adipose tissue and brown fat but that both spring from a common ancestor segregated from the primitive mesenchyme.

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LYMPHOSARCOMA OF THE GASTRO-INTESTINAL TRACT

REPORT OF TWENTY CASES

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TWENTY CASES of lymphosarcoma of the gastro-intestinal tract have been treated in the New York Hospital during the past nine years. It is with the purpose of bringing out certain points in the treatment and presenting a follow-up study of these cases that this report is made.

No attempt at complete review of the literature will be made. For more extensive reviews, reference may be made to articles by Ullman and Abeshouse, Sugarbaker and Craven, Stout, and Madding and Walker. Stout collected 19 cases of lymphosarcoma of the gastro-intestinal tract encountered over a period of 21 years (1915-1935) at the Presbyterian Hospital in New York. He did not designate the site of occurrence of these tumors but stated that there were six five-year survivals. Madding and Walker reported 41 cases of lymphosarcoma of the stomach from the Mayo Clinic and concluded that the treatment should be surgical removal when possible, with roentgenotherapy administered as an adjunct. Abeshouse and Ullman, in 1932, compiled from the literature reports of 126 cases of lymphosarcoma of the intestines and stated that of 109 in which the site of the lesion was recorded, 77 were in the small intestine (36 in the ileum) and 32 in the large intestine. They found that lymphosarcoma was accompanied by metastases in practically every case. The average duration of life was 19 months for 85 cases upon whom operation was undertaken, ten cases were alive and well five or more years after operation with no sign of recurrence. McCann, in 1930, reported 32 cases of lymphosarcoma of the stomach.

Raiford (1932) reported 88 cases of tumors of the small intestine of which 21 were lymphoblastoma, one was from the duodenum, 18 the ileum and two from sites not determined. Warren and Lulenski (1942) reported 15 cases of lymphosarcoma, 13 of which were subjected to surgery with two apparent five-year cures. The average survival time was 2.5 years.

The relative frequency of lymphosarcoma in the esophagus, duodenum and appendix is attested by reviews such as those of Corner and Fairbanks, Friend, Crowthers, Goldstein, Libman and Eisenbrey. Corner and Fairbanks, in 1904, collected from the literature 14 sarcomas of the esophagus, one a lymphosarcoma which is not described other than by diagnosis. They also cite two instances of "sarcoma" of the appendix without further elucidation. Friend reported 20 collected cases of sarcoma of the appendix, four of these, including his own case, showed the microscopic findings characteristic of lymphosarcoma. Four apparently authentic cases of lymphosarcoma of the duodenum are cited by Crowther.

Incidence—In 149,469 admissions to the New York Hospital between 1933 and 1942, 20 cases of lymphosarcoma of the gastro-intestinal tract were observed, the diagnosis in all of these being confirmed by microscopic examination. During the same nine-year period 68 carcinomas of the esophagus, 384 carcinomas of the stomach, 11 malignant lesions of the small intestine, and 568 carcinomas of the large intestine and rectum were encountered. By comparing these figures to those which appear in Table I, the relative frequency of lymphosarcoma in our series may be seen. It is an incidence of one case of lymphosarcoma to every 51 cases of carcinoma, or 1.9 per cent of all malignant lesions of the gastro-intestinal tract. This percentage is considerably higher than that of 0.9 per cent given by Warren and Lulenski, who included in this figure their cases of Hodgkin's disease.

TABLE I

LOCATION OF LYMPHOSARCOMA IN THE GASTRO INTESTINAL TRACT	
Location	No. of Cases
Esophagus	1
Stomach	7
Small intestine	3
Jejunum	1
Ileum	2
Appendix	2
Large intestine	7
Cecal region	2
Transverse colon	1
Sigmoid colon	1
Rectum	3
Total	20

In this series there were 13 males and 7 females. The ages ranged from 45 to 71 years, 12 of the cases being between the ages of 40 and 60 (Table II). The average age was 43.2 years.

TABLE II

AGE INCIDENCE OF LYMPHOSARCOMA

Age in Years	No. of Cases
0-10	2
10-20	1
20-30	1
30-40	4
40-50	3
50-60	5
60-70	3
70+	1
Total	20

CLINICAL MANIFESTATIONS AND PREOPERATIVE DIAGNOSIS

Esophagus—The single case (Case 1) of lymphosarcoma of the esophagus occurred in a 62-year-old woman, who was admitted complaining of vomiting for five months, during which time she had noted epigastric pain and burning and the sensation that food stuck in her chest. She had lost 60 pounds in one

year, and had had one tarry stool. There were no significant physical findings except evidence of marked loss of weight. There was nothing in the clinical picture to distinguish this from any other malignant lesion of the lower end of the esophagus.

Laboratory data other than roentgenologic were unremarkable. Blood count and examinations of the stool for occult blood were negative.

Gastro-intestinal roentgenologic series (Fig 1) showed a filling defect in the cardia of the stomach, with narrowing and irregularity of the lower end of the esophagus and a penetrating defect of the lower border of the tumor. *Roentgenologic Diagnosis* Carcinoma of esophagus.



FIG 1—Case 1. Roentgenogram showing filling defect in the cardia of the stomach, with narrowing and irregularity of the lower end of the esophagus and a penetrating defect of the lower border of the tumor.

FIG 2—Case 8. Roentgenogram showing extensive involvement of the stomach by tumor and typical whorl-like formation along the lesser and greater curvatures in the region of the antrum.

Stomach—In this group of seven cases there were four females and three males, their ages varying from 43 to 65. The chief complaints elicited were weakness, pallor, anorexia, abdominal pain, "indigestion," nausea and vomiting. The duration of the symptoms varied from 2 1/2 weeks to 7 months. Six of the seven patients had epigastric pain and five had had vomiting. Three patients had noted tarry stools. There was a history of loss of weight in five patients varying from 9 to 40 pounds. Other symptoms were dysphagia, mass in the upper abdomen, and mass in the right axilla.

Physical examination showed five patients to be afebrile while two had slight fever (38° – 38.6° C). The state of nutrition in four patients was good on admission but there was evidence of loss of weight in three. Only

two had palpable lymph nodes (right axillary in Case 8 and cervical in Case 6) Abdominal examination in four showed the presence of an epigastric mass, in three the mass was slightly tender Rectal examination revealed an irregular, firm and nontender mass in the cul-de-sac of one patient

Laboratory findings were of no value in arriving at an accurate diagnosis Four patients had moderate secondary anemia, the hemoglobin values being 9 to 12 Gm, and the erythrocyte count 3.3 to 3.8 million The total leukocyte count was normal in all but one, in which it was 13,000, the differential count was normal in all cases No case of lymphocytosis was observed The stools were guaiac-positive in five instances Gastric analysis was performed in six cases, in four there was no fasting free acid, and Case 4 had no free acid after the injection of histamine, the remainder had from 12 to 80 units of free acid

Two patients were subjected to gastroscopy In Case 3 a granular area without ulceration was seen on the lesser curvature, and in Case 4 the gastric wall was stenosed and rimmed with tumor The impression in both was gastric carcinoma

All patients had gastro-intestinal roentgenograms, a preoperative diagnosis of lymphosarcoma was made in one (Fig 2, Case 8) and gastric carcinoma in seven The location of the tumors was as follows Pylorus, 5 (Cases 3, 4, 5, 6 and 7) Entire stomach, 1 (Case 8) Greater curvature, 1 (Case 2)

In one of the cases in which the lesion was found in the pylorus (Case 3), it also extended up the lesser curvature, where a large crater was observed In another patient with a pyloric tumor (Case 7), a defective duodenal cap was demonstrated, this patient had an ulcer history of one year's duration

Small Intestine—The small intestine was the site of lymphosarcoma in three patients, all of whom were males In one the lesion was in the jejunum and in the other two in the ileum All patients had a history of abdominal pain, nausea and vomiting Two had manifestations of intestinal obstruction One patient had gross blood in the stool and two had tarry stools Only one patient had lost weight, in his case 30 pounds in three months

Physical examination showed increased temperature (38° – 39.6° C in Case 9) before operation in one, the others were afebrile All patients showed evidence of recent decrease in weight, although only one had given a history of loss of weight Two had palpable nodes in the cervical, axillary and inguinal regions Rectal examination was negative in all cases

One patient had a marked secondary anemia (Case 10, hemoglobin 8 Gm, erythrocyte count 3.1 million), the other two did not have anemia The white cell and differential counts were normal in all three instances The stools of two patients were positive by the benzidine test (Cases 9 and 10)

Roentgenologic studies were made in only two patients One (Case 10) had a barium enema, which showed a normal colon A diagnosis of lymphosarcoma was made in one patient (Case 9) by means of a gastro-intestinal series, which showed dilatation of the second portion of the duodenum and proximal portion of the jejunum

Appendix—There were two cases of lymphosarcoma involving the appendix, both were females, and their ages were 39 and 47 years

Their symptoms and physical findings were as follows. One patient had had pain in the right lower quadrant of the abdomen for two days, with nausea and vomiting, and she gave a history of a similar episode six years previously. The physical findings were typical of appendicitis. Her temperature was 39.8°C , she had diffuse rigidity in both lower quadrants and marked tenderness over McBurney's point. No mass was palpated and no tenderness elicited on rectal examination.

The second patient had no symptoms referable to the gastro-intestinal tract. She was admitted to the hospital for bleeding from a fibromyoma of the uterus. A mass was palpable in the left adnexal region. There were no other physical signs of significance.

Neither patient had palpable lymph nodes. Neither roentgenologic studies nor stool examinations were made.

Large Intestine—Lymphosarcoma of the large intestine occurred in seven patients, all of whom were males with ages ranging from 45 to 65 years. The sites were: Cecum (involving appendix and terminal ileum), 2; Transverse colon, 1; Sigmoid colon, 1; Rectum, 3.

The chief complaints were abdominal pain, pruritus ani, constipation, abdominal mass, and rectal bleeding. The duration of symptoms varied from four weeks to four years. Other symptoms were diarrhea, distention, and increased temperature. One patient had had a duodenal ulcer for three years. Abdominal pain was present in four cases, vomiting in only one, symptoms of intestinal obstruction in one, bloody stools in three, and loss of from 9 to 25 pounds in weight in four.

Physical examination revealed that all patients were afebrile on admission. Four showed evidences of loss of weight. In only three patients were there palpable nodes, all of these being in the inguinal region. Abdominal masses were palpable in three instances, epigastric in one, lower right quadrant in one, and lower left quadrant in the third. Abdominal tenderness was present in four patients. Rectal examination in five of the seven cases disclosed the presence of a mass, two of the lesions appearing clinically to be rectal polyps.

Laboratory data showed the presence of secondary anemia in two cases (Cases 13 and 17—hemoglobin 9.6 and 10.2 Gm, respectively). In one case (Case 17) there was a leukocytosis of 21,700, with 58 per cent lymphocytes, this was the patient with a large inoperable tumor of the sigmoid, who later developed metastases in distant nodes. In the other cases the total leukocyte and differential cell counts were within normal limits.

Proctoscopic examinations were made in five of the seven patients, and normal rectal mucosa was found in two. In one, examination showed an ulcerated, fungating lesion 7 cm above the internal sphincter on the left rectal wall (Case 17), and in another, a reddened mass on the right wall 2 x 3 cm in size, with a broad pedicle, and no ulceration (Case 20). Case 18

presented a 7-mm polypus anteriorly about 5 cm from the anus, and Case 19 had four rectal polypi

Barium enemas were given in five instances, and showed normal colons in two cases with rectal lesions. In two cases there were filling defects in the cecum, one (Fig 3) showing an intussusception of the terminal ileum into the ascending colon. In one, a filling defect was demonstrated in the distal transverse colon (Fig 4) 10 cm proximal to which a second constricting lesion was seen. The roentgenologic diagnosis was carcinoma in two, lymphosarcoma in one, and intussusception in one case.



FIG 3—Case 12. Barium enema demonstrating intussusception of the terminal ileum into the ascending colon.

FIG 4—Case 16. Roentgenogram showing defect in the distal transverse colon and a second constricting lesion proximal to it.

OPERATIVE FINDINGS AND THERAPY

Seventeen operations were performed upon 16 patients, excluding exploratory celiotomies and biopsies. Abdominal explorations and biopsies were undertaken in four cases, excision of a lymph node for microscopic examination once, and proctoscopy and biopsy once (Table III).

Esophagus—At operation this tumor was found to involve the distal 2.5 cm of the esophagus, extending to the cardia of the stomach, without demonstrable metastases to the liver or regional lymph nodes.

In this single case (Case 1), exploratory celiotomy and ligation of the left gastric artery was done, followed five days later by resection of the lower esophagus and cardia of the stomach, with esophagogastrostomy by the thoracic approach.

Stomach—The main regions of involvement by tumor at operation were the lesser curvature in two cases, the greater curvature in two cases, and

TABLE III
OPERATIVE PROCEDURES

Resections	
Gastric resection	
Wedge resection	
Subtotal resection	1
Resection of jejunum	5
Appendicectomy	1
Exploration and ligation of left gastric artery	2
Resection lower esophagus with esophagogastrostomy	1
Excision of rectal polyp	2
Palliative	
Partial reduction of intussusception	1
Ileo ileostomy	1
Ileocolostomy	1
Cecostomy	1
Diagnostic	
Lymph node biopsy	1
Proctoscopy and biopsy	1
Exploratory celiotomy and biopsy	4
Total	23

the antrum and posterior wall in one. In one case two thirds of the stomach was involved, with extension into the abdominal wall. In the remaining case, which was not explored—the diagnosis being made by supraclavicular lymph node biopsy—gastro-intestinal series showed involvement of the entire stomach.

In all cases but one the tumor was large and resection of at least two-thirds of the stomach was necessary in four cases. In none was the diagnosis of lymphosarcoma made at operation. Involvement of the regional nodes was noted in four cases, absent in one, and not mentioned in one. Liver metastases were not present.

One patient was subjected to excision of a supraclavicular lymph node, one to a wedge resection of the stomach, and the other five to subtotal gastric resections.

Jejunum—In this single case there were three separate lesions, 15 cm apart, with partial obstruction causing dilatation of the duodenum and proximal jejunum. The operation performed was a resection of the proximal 40 cm of jejunum, removal of mesenteric nodes, which contained metastases, and lateral anastomosis.

Ileum—In one case there was a tumor, 45 cm proximal to the ileocecal valve, obstructing the lumen and involving the mesenteric nodes. An enter-enterostomy and biopsy of lymph nodes was done.

In the second case the lesion lay in the terminal ileum, producing intestinal obstruction. A palliative ileocolostomy was performed.

Appendix—In one case the appendix contained a wart-like swelling in its middle third, in the other no tumor was noted on gross inspection at operation. Appendicectomy alone was performed in both instances.

Large Intestine—In one case the cecum, the appendix and the terminal ileum were involved in a hard, nodular mass causing intussusception of the terminal ileum extending as far as the descending colon. Partial reduction of the intussusception was carried out, followed in seven weeks by an exploratory celiotomy which revealed that the lesion was inoperable and biopsy alone was performed. Large retroperitoneal masses were found. A second case, with involvement of the cecum, the appendix and the terminal ileum, had an appendectomy and biopsy of lymph nodes.

TABLE IV
SUMMARY OF RESULTS OPERATIVE AND ROENTGENOTHERAPY

	No of Cases	Follow-up Years Months	
Operative and Roentgenotherapy			
Living without recurrence	2		
✓ Case 5		1	
Case 9		9	5
Living with recurrence	1		
✓ Case 3		3	5
Dead	3		
Case 4		1	10
✓ Case 6			10
✓ Case 7			1
Roentgenotherapy alone			
Living without recurrence	2		
Case 10		9	6
Case 20		1	8
Living with recurrence	1		
Case 17		4	2
Dead	3		
Case 11		6	
Case 12			4
Case 16			2
Not followed	1		
Case 13			
Operation only			
Living without recurrence	5		
Case 1		2	4
Case 14		4	3
Case 15		2	2
Case 18		2	4
Case 19		2	2
Living with recurrence	0		
Dead without recurrence	1		
✓ Case 2		7	2
No treatment	1		
Dead			
✓ Case 8			½
Total	20		

The transverse colon was the site of involvement in one case. In the midportion there was an annular, freely movable tumor, 6 cm in length, with a second similar lesion 15 cm distal to the first, with infiltration of the gastro-colic ligament and metastases in the liver. Biopsy only was feasible.

In the isolated instance in which the sigmoid was the site of lymphosarcoma, exploratory celiotomy revealed 12 cm of the sigmoid colon to be shrunken, indurated, and to contain palpable nodules, which were biopsied.

Rectum—One case had four polypi 7 cm from the mucocutaneous junction, another had a polypus about 2 cm above the internal sphincter, and the

third presented a 2 x 3 cm mass just above the internal sphincter. In the first two patients excision of the rectal polyp¹ was performed and a biopsy taken in the third.

ROENTGENOTHERAPY

Thirteen of the 20 patients were given roentgenotherapy. Two of these (Cases 12 and 16) tolerated radiation so poorly that it was discontinued before the outlined dosage could be given, both of these patients died of fulminating lymphosarcoma (Table IV).

TABLE V
MICROSCOPIC PATHOLOGY

Microscopic Pathology	No of Cases	Dead	Alive with Recurrence	Alive without Recurrence
Reticulum cell sarcoma	1	0	1	0
Large cell lymphosarcoma	4	3 (or 4*)	7*	
Small cell lymphosarcoma	12	4	0	8
Giant follicle sarcoma	3	1	1	1

*Case 13 not followed

Six of the patients were subjected to resection of the tumor followed by prophylactic roentgenotherapy. Case 7 died of postoperative hemorrhage 33 days following gastric resection after having received 330 r through three upper abdominal portals. Three patients received roentgenotherapy in addition to palliative procedures, four received roentgenotherapy alone and in six resection only was performed.

In all instances that tolerated the therapy the response to the roentgen-ray was good as far as the local lesion was concerned. Palpable masses often melted away dramatically following irradiation. One patient with involvement of the cecum received 700 r through four portals to the right abdominal mass, which diminished in size but rapidly became larger when the therapy had to be discontinued because the patient developed marked anemia and leukopenia.

In this small series of cases the prognosis was better in the small cell lymphosarcoma than in the other types of tumor (Table V). The roentgen-ray dosage varied considerably over the period of nine years but, in general, amounted to from 1400 to 2000 r directed at the region involved through two to four portals.

PATHOLOGY

Gross Pathology—In general, lymphosarcoma arises in the submucous layers of the intestinal tract and infiltrates the surrounding tissues. Usually all of the layers of the intestinal tract except the serosa are invaded but in two cases there was extension through the serosal surface of the stomach and invasion of the anterior abdominal wall. Involvement of regional nodes occurs frequently and was present in 12 cases in this series.

At operation, the gross appearance of lymphosarcoma differs sufficiently

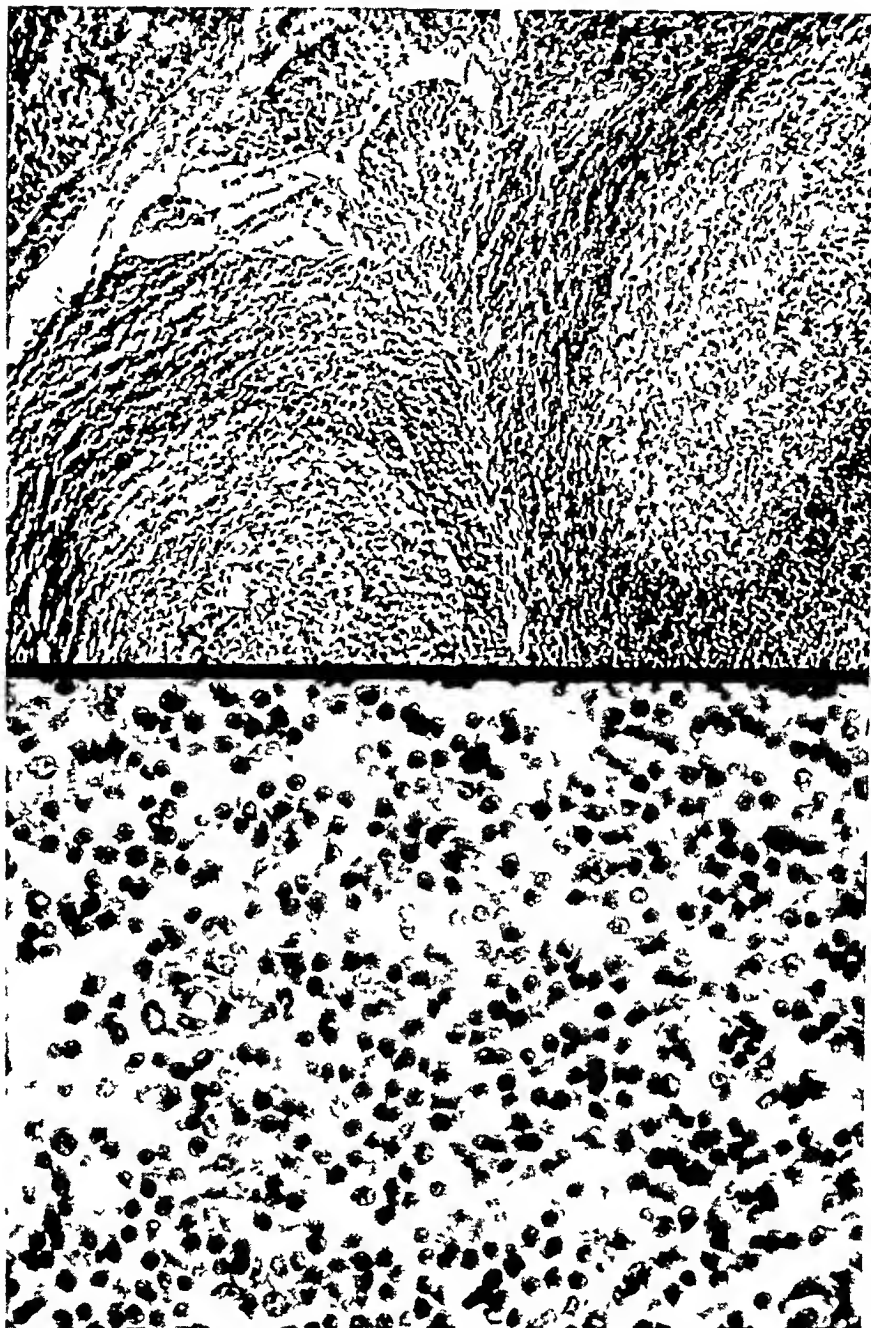


FIG 5—Case 17 (Sigmoid) Photomicrograph showing enlarged lymph follicles characteristic of giant follicle lymphosarcoma ($\times 150$)

FIG 6—Case 1 (Esophagus) Photomicrograph showing uniform small lymphocytes and scant stroma in a small cell lymphosarcoma ($\times 600$)

from that of carcinoma to be identified or suspected at operation. The lymphosarcomatous mass usually is firm but softer than the hard consistency of carcinoma, it is friable, often rubbery and nodular, and the cut-surface resembles the whitish-grey homogenous appearance of lymphoid tissue. Ulceration is frequent and occurred in at least five of the cases reported.

Microscopic Pathology—The tumors in this series were classified as (1) nodular lymphosarcoma, (2) small round cell lymphosarcoma, (3) large round cell lymphosarcoma, and (4) reticulum cell lymphosarcoma. Nodular lymphosarcoma (giant folliculoma or Brill-Symmer's disease, Fig 5) is characterized by enlargement of the lymph follicles, composed of cells with

large vesicular nuclei and showing numerous mitoses, they should not show phagocytosis. The large and small cell lymphosarcomas (Figs 6, 7 and 8) both show disruption of the normal lymph node architecture, invasion of the capsule, numerous mitoses, with predominance, on the one hand, of the



FIG 7—Case 15 (Appendix) Cross section of lumen filled with large lymphoid follicles which replace the mucosa and submucosa of the appendix (× 10)

large lymphoblast and, on the other, of the small lymphocyte. Usually the struma is scanty. Reticulum cell sarcoma (Fig 9) is recognized by the sheets of cells, often crescentic, tailed or polyhedral in shape, with large clear nuclei, by the loss of the normal lymph node architecture and the demonstration of the characteristic reticulum fibers by special stains (notably the method of silver impregnation of Foot and Foot).

The relation of histologic pattern to survival time is illustrated in Tables V and VI.

All cases were reviewed by Dr N C Foot, with the authors, and were verified by him as being lymphosarcoma of the groups as classified above.

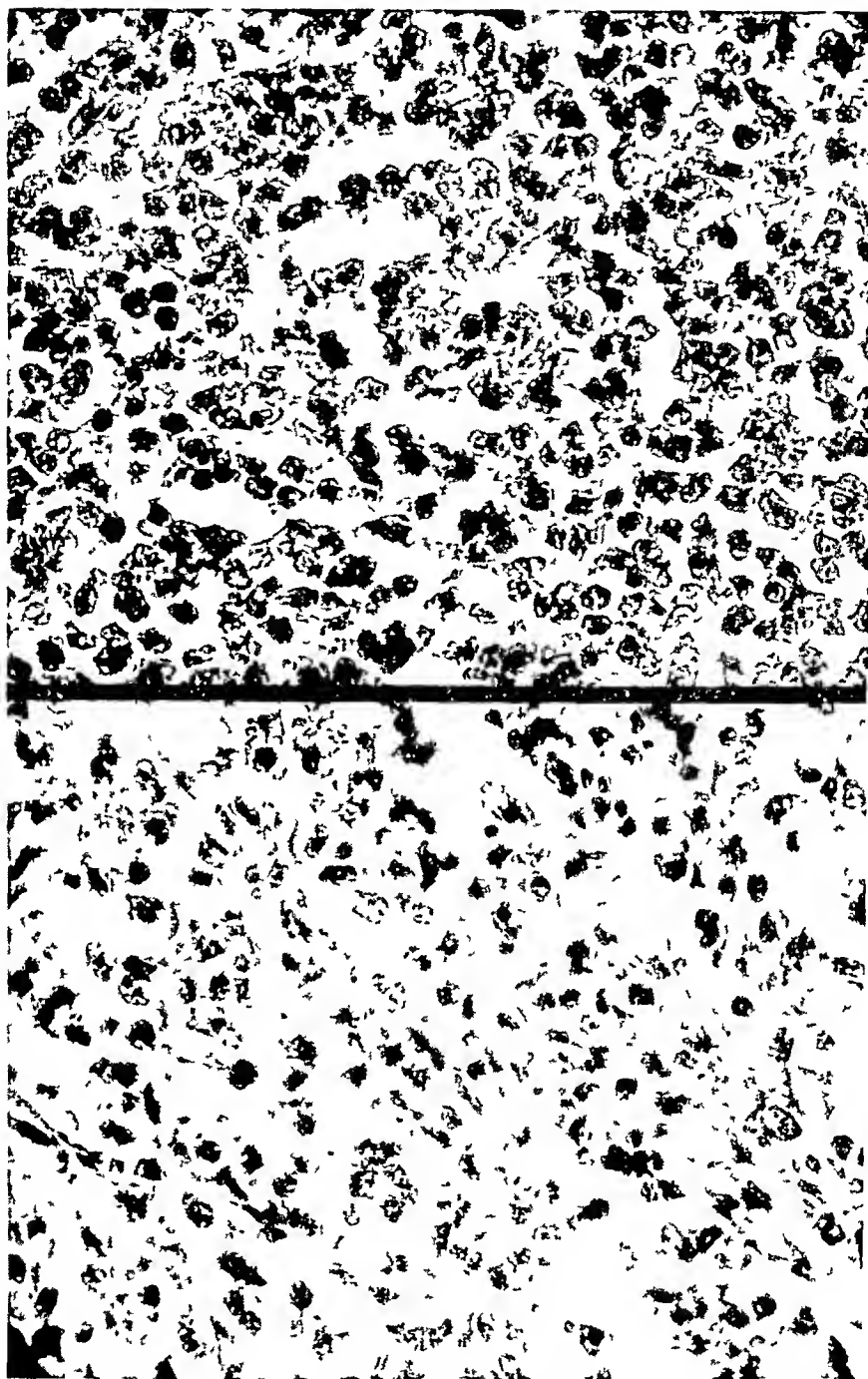


FIG 8—Case 9 (Jejunum) Photomicrograph showing uniform large lymphoblasts with numerous mitoses and scant stroma ($\times 600$)

FIG 9—Case 3 (Stomach) Photomicrograph of reticulum cell sarcoma demonstrating large reticulum cells with tailed and polyhedral cells ($\times 600$)

DISCUSSION—*Diagnosis* A diagnosis of lymphosarcoma of the gastro-intestinal tract seldom is made before histologic examination, due to the fact that the signs and symptoms produced by this type of malignant growth are little different from those caused by other gastro-intestinal neoplasms

Although there is nothing specific in the clinical manifestations of these patients which might lead to a diagnosis of lymphosarcoma, the appearance of the mass soon after the onset of symptoms is suggestive of this type of tumor, as is a large mass in a patient in good general condition ¹⁴

A roentgenologic diagnosis of lymphosarcoma was made in only three cases in this series. It is difficult to differentiate lymphosarcoma by roentgenologic examination because the picture so closely resembles that of carcinoma, however, there are diagnostic points which suggest lymphosarcoma, *ie*, (1) the large size of the lesion in relation to the short duration of symptoms,¹⁴ and (2) the presence of whorl-like defects in the barium outline (Figs 2 and 10). In the diagnosis of neoplasms of the colon, a double or



FIG 10—Case 5. Roentgenogram of stomach showing whorl-like defects along the greater curvature.

an usually long mass is suggestive of lymphosarcoma. Tuberculous colitis and regional colitis must be ruled out before this diagnosis is made. When the above characteristics are present, the diagnosis of lymphosarcoma should be made, unfortunately, however, these roentgenologic findings often are absent and consequently the preoperative diagnosis usually is carcinoma.

Blood counts were throughout of no aid in diagnosis, the count having been unusual in only one case.

RESULTS OF TREATMENT

The survival of the patient is influenced more by the site and extent of the growth than by the histologic type of neoplasm or the age of the patient. The prognosis largely depends upon whether the lymphosarcoma is localized and can be treated as an isolated lesion, or whether a general spread has occurred.

The six patients in whom the lesion was sufficiently localized to allow extirpation, have survived from two to seven years without receiving roentgenotherapy. The location of these tumors was strikingly varied, involving as they did the esophagus, stomach, appendix and rectum. However, in all six cases the tumor was well-localized and without apparent lymph node involvement. One of these patients died later of an unrelated condition, without evidence of recurrence.

Of the six patients treated with roentgenotherapy alone, only two (Cases 10 and 20) are without evidence of recurrence. In two cases (Cases 5 and 9) resection of the lesion was followed by irradiation without evidence of a return of tumor. In four, resection followed by irradiation gave poor results. In one case (Case 6) irradiation was started five months after operation, obviously too late for maximum prophylactic value. Case 16 tolerated the therapy so poorly that it was discontinued. Case 4 had a large lesion originally and had recurrences involving the left inguinal and iliac chains of nodes. Still later she developed a large cutaneous mass in the left posterior thoracic region and shortly thereafter she expired. In general, the appearance of subcutaneous masses or nodules in lymphosarcoma is of grave prognostic significance. In contradiction to reports by some observers^{15, 16} the reticulum cell sarcoma in this series was quite radiosensitive. The patient who had this type of tumor had had several recurrences over a period of three years, each time the tumor melted away rapidly after roentgenotherapy.

Nine patients are alive and without recurrence at present, their original tumors were located in the esophagus, stomach, jejunum, ileum, appendix (two) and rectum (three). One case of lymphosarcoma of the stomach died seven years and two months after operation from hypertensive cardiovascular disease, without evidence of recurrence.

SUMMARY

A series of 20 cases of microscopically proven lymphosarcoma of the gastro-intestinal tract is presented—the lesion having arisen in all areas of the gastro-intestinal tract except the duodenum.

The clinical manifestations, laboratory, roentgenologic and operative findings are reviewed and the treatment by operation and irradiation described.

Cures of five or more years were obtained after roentgenotherapy alone in one case (Case 10), after surgical extirpation in one (Case 2), and after a combination of the two in one (Case 9). Nine cases (47 per cent of cases followed) are alive and well at present, without evidence of recurrence from one year to nine years and five months since the diagnosis was established.

The mortality at the present state of follow-up is 42 per cent (8 of the 19 cases followed) From the time of establishment of the diagnosis in eight patients who died, the average duration of life was 24 months The average for the entire series (including those now alive) was 37 months The latter figure is of little importance because of the short period of time which has elapsed in six patients since the establishment of the diagnosis

CONCLUSIONS

Lymphosarcoma may be found at any point in the gastro-intestinal tract, including the appendix

The preoperative diagnosis of lymphosarcoma of the gastro-intestinal tract is rarely made

The prognosis is most favorable in instances suitable for complete extirpation, and we think that resection should be undertaken, if technically possible, although in this small series of cases the duration of life was apparently shorter following a combination of resection and roentgenotherapy (11 months for three patients who died, 33 months for six patients, including three still living) than after roentgenotherapy alone (26 months for three patients who died, 44 months for six patients, including three living) Roentgenotherapy alone occasionally results in apparent cure

Roentgenotherapy should be given in every case of lymphosarcoma of the gastro-intestinal tract unless the operator and surgical pathologist are certain that the lesion has been completely eradicated Irradiation should be started as soon as the wound is healed and the patient is ambulatory

We are indebted to Dr John L Sullivan and Dr Harold Temple of the Roentgenologic Department of the New York Hospital, and to Dr N C Foot of the Department of Surgical Pathology for their valuable suggestions and advice

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HYPERTROPHIC PYLORIC STENOSIS IN ADULTS

REPORT OF TWO CASES

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HYPERTROPHIC PYLORIC STENOSIS of infancy is a well recognized disease entity. It is not fully appreciated, however, that the same condition may be found in adults as well. Some one hundred odd cases of simple pyloric muscle hypertrophy in adults have been reported in the literature¹ and, no doubt, numerous other unrecorded cases have been encountered. Our sum total of knowledge regarding this peculiar condition as it occurs in adults is meager indeed. The etiology of the disease is still obscure despite a host of speculative theories, the clinical features show a wide variation and there is no uniformity in the method of management. For these reasons we considered it would be of value to report two cases of simple hypertrophic pyloric stenosis in adults which we have recently studied. Not only do these cases serve to call attention to the condition, but they also are of interest because of the possibility in each that psychogenic factors played an important etiologic rôle.

CASE REPORTS

Case 1—M E P, white, male, age 39, first experienced inconsistent, dull, gnawing epigastric pain in 1937. This tended to appear about two hours after meals, was commonly associated with vomiting, and was alleviated by the ingestion of milk or soda. The initial episode lasted about one week and then spontaneously disappeared. Subsequently, there occurred similar attacks of some two to three weeks' duration, the last of which was in 1940. Though married and with a daughter of about 15 years of age, his married life was unpleasant and disruptive. His livelihood was earned from commissions made in his capacity as a traveling salesman. In latter years he had acquired a mistress, and it became necessary for him to increase his earnings in order to support her as well as his family. As a consequence, he redoubled his efforts at selling, tending to work harder, longer, and with greater zeal. On several occasions when he was about to clinch an important sale he was conscious of becoming exceedingly tense and tremulous. It was common for him at these times to experience epigastric pain entirely similar to that which had been recurring in attacks since 1937.

He performed his duties in the army without any digestive difficulty from the time of his induction in June, 1942, until early February, 1943. During the latter period epigastric distress reappeared along with vomiting and he was required to seek hospitalization. After appropriate study a diagnosis of gastric ulcer was made and, on April 1, 1943, he was transferred to Tilton General Hospital.

On admission, he was ambulatory and in no acute distress. Physical examination was essentially negative except for some epigastric tenderness. Blood studies, including red and white cell counts, urea nitrogen, chlorides, total protein, albumin and globulin values were all within normal limits. The Wassermann and Kahn tests were negative. Fractional gastric analysis with an Ewald meal showed a maximum free acid of 8 and a maximum total acidity of 30 clinical units, impairment in motor function of the

FIG 1



FIG 2

FIG 1—Case 1 Roentgenogram showing narrowing of the pars pylorica. Note smooth and regular contour of the stomach at the antral extremity of the narrowed area.

FIG 2—Case 1 One of a serial roentgenogram showing, again, the marked narrowing of the pars pylorica. Note regular straight folds indicating absence of mucosal involvement.

stomach was indicated by some delay in emptying of the test meal. Gastroscopy revealed a normal appearing mucosa. Roentgenologic examination of the stomach and duodenum disclosed a persistent narrowing of the distal end of the stomach. This area was tubular in character and peristalsis did not pass through it. At the lower extremity of the narrowed area, on its lesser curvature side, was a persistent double incisura with an interposed teat-like projection (Fig 1). The walls of the antrum appeared thickened and could not be distended on forced filling. Despite the narrowing and irregularity of the pars pylorica, the mucosa in this region appeared to be intact (Fig 2). The radiopaque meal readily passed through the pylorus and at the end of six hours the stomach was completely empty. These findings were interpreted as indicative of either a constricting type of malignant infiltration or a benign juxta-pyloric ulcer associated with spasm and cicatrization.



FIG 3—Case 1. Histopathologic section of the gastroduodenal junction showing marked hypertrophy of the muscularis of the pars pylorica.

On a rigid ulcer regimen the patient remained asymptomatic, and even gained some five pounds in weight. However, roentgenologic reexamination after three weeks of this program showed no change in the appearance of the antrum. In view of his age, the hypoacidity, and the roentgenologic findings, it was felt that malignant infiltration could not be excluded other than by surgical exploration. Accordingly, May 4, 1943, a celiotomy was performed under general anesthesia. The stomach was found to be normal except for moderate thickening and induration of the pars pylorica, the duodenum was normal, no enlarged lymph nodes were found, and no lesions indicative of metastatic malignancy could be identified in the liver or other adjacent structures. Since a neoplasm of the stomach could not be definitely excluded on the basis of inspection and palpation alone, a subtotal antecolic Polya-type of gastric resection was performed.

Histopathologic Examination—Gross "The specimen consists of the distal segment of the stomach. The pyloric ring measures 5 cm in circumference and the line of section measures 15 cm in circumference. The lesser curvature measures 45 cm and the greater curvature 9 cm. There are large dilated veins seen on the serosa along the lesser curvature. The mucosa along the lesser curvature, extending from the anterior to the posterior walls, appears granular, reddened, and thickened. There are several small scattered mucosal hemorrhages. The muscle in the pylorus shows considerable increase in size in all dimensions. It forms a wide, thick, garter-like band, which is

2 cm in width and 0.6 cm in thickness. The adjacent stomach musculature is also somewhat thickened. The muscle bundles are translucent and glistening and are separated by white firm connective tissue.

"Microscopic Examination A—Pylorus Marked congestion with small hemorrhages and some edema is present in the epithelium of the pyloric mucosa. There is a large submucosal hemorrhage. A cellular infiltration exists throughout the mucosa, the predominant cell being the plasma cell, but there are also a moderate number of eosinophils and polymorphonuclear leukocytes. There is some edema between the acini.

"Examination of the pyloric musculature reveals it to be thickened (Fig 3). The smooth muscle forms a large wide oval area composed of bundles of muscle which have apparently undergone both hyperplasia and hypertrophy. There is a small amount of connective tissue separating some of the muscle bundles, but the predominating tissue is muscle.

"B—Granular Area on the Lesser Curvature The muscularis is moderately thickened. In the mucosa, there is a marked congestion of capillaries along with a moderate number of polymorphonuclear leukocytes and a few eosinophils. Several lymphoid follicles are present the germinal centers of which show moderate hyperplasia. The tissue in the submucosa is edematous and of a loose areolar character. Scattered throughout this area are numerous lymphocytes and a few polymorphonuclear leukocytes and eosinophils. There is a marked congestion of the serosa with scattered hemorrhages in the serosal fat. An occasional small artery in the serosa shows marked obliterative changes, some perivascular focal collections of lymphocytes are present.

"C—Prepyloric Region Diffuse infiltrations of plasma cells with some polymorphonuclear leukocytes and eosinophils are seen. Some lymphoid follicles show hyperplasia of the centers. The submucosal tissue is loose and areolar.

"D—Distal Line of Resection The changes here are similar to those described in the above sections.

"Pathologic Diagnoses 1 Hypertrophic pyloric stenosis 2 Chronic gastritis, non-specific 3 Hypertrophy of the muscularis of the antrum, moderate."

Subsequent Course—The postoperative course was without complication except for some pain and weakness in the left arm, which the patient attributed to intravenous therapy he had received. This complaint afforded us further insight into the personality of the patient and will be described in more detail later. Roentgenologic examination on June 1, 1943, revealed no abnormalities in the remnant of the stomach or in the anastomotic area, the ostium functioned well, and at the end of three hours only a trace of the radiopaque meal remained in the stomach. Fractional gastric analysis, June 2, 1943, showed an achlorhydria both to an Ewald meal and to histamine. Gastroscopic examination, June 8, 1943, disclosed a patent gastrojejunostomy, without any evidence of mucosal changes in the remnant of the stomach. The patient remained symptom-free and was discharged from the hospital, July 1, 1943, in excellent condition.

Case 2—J. T. O., white, male, age 37, was inducted into the army in January, 1943. For many years he had been compelled to follow one type of employment during the day, and another by night in order to support his seven children and pay for the cost of institutional care for his wife, who was an inveterate drunkard and whose behavior was a constant source of embarrassment and concern to the patient. He volunteered the information that abdominal distress would be experienced at times when his social difficulties were particularly trying. The discomfort was usually of very short duration and he gave it little thought. In the early part of February 1943, he began to experience regularly recurring, upper abdominal discomfort characterized, in the main, by a sensation of fullness after eating. The postprandial distress varied in intensity, was intermittent, and was relieved by vomiting. At times there was a burning sensation in the epigastrium associated with sour eructations. These would be alleviated by the ingestion of milk or aluminum hydroxide gel. Symptoms recurred almost daily throughout March, being worse after the midday meal and two to three

hours after the evening meal. His appetite remained good, but he had lost about 15 pounds in weight. There was no severe pain, hematemesis or melena. Since the onset of his present illness it was apparent to him that his symptoms were decidedly aggravated by episodes of worry and strife. In April, 1943, he was forced to seek medical aid despite his disinclination to do so. Evidence was found of pyloric obstruction and, May 21, 1943, he was transferred to Filton General Hospital.

On admission, he was ambulatory and in no acute distress. A moderate degree of undernourishment was apparent. Enlargement of the stomach, with a loud succussion splash, could be elicited on abdominal examination, peristalsis was not visible and no masses could be felt. Blood studies, including red and white cell counts, urea nitrogen, chlorides, carbon dioxide combining power, total protein and albumin and globulin values were all within normal limits. The Wassermann and Kahn tests were both negative. An overnight retention of food, with a fasting residuum of 500 cc., was found in the stomach. The free acid of the contents of the fasting stomach measured 25 and the total acidity 58 clinical units. On fractional gastric analysis no free acid was exhibited in response to an Ewald meal, but after histamine a maximum free acid of 27 and a maximum total acidity of 55 clinical units was obtained. Gastroscopic examination showed some distortion in the anatomic alignment of the distal antrum, the pylorus could not be seen, and there was no evidence of gastritis. Roentgenologic studies of the stomach and duodenum, May 25, 1943, disclosed an hypotonic, slightly enlarged stomach. The contents of the fasting stomach had been evacuated by tube just prior to the roentgenologic examination, yet nonopaque material was found in the stomach at the time of examination. The pylorus was markedly narrowed and in the pyloric canal a persistent niche was noted (Fig 4). A conspicuous finding was a marked indentation of the base of the duodenal bulb which was accentuated even more in the compression films (Fig 5). Six hours after its ingestion about 60 per cent of the opaque meal was still retained in the stomach. The changes observed were interpreted as due to pyloric obstruction and thickening secondary to pyloric ulcer.

A rigidly enforced stomach-rest regimen was instituted. After almost three weeks of this program the pyloric obstruction, both clinically and roentgenologically, was essentially unchanged, even though the patient was rendered symptom-free. The failure of the pyloric obstruction to show any satisfactory response to a rigid medical regimen during this period of time was felt to warrant surgical intervention. Accordingly June 14, 1943, a celiotomy was performed, under continuous spinal anesthesia. The stomach was found to be a little dilated and at its pyloric extremity a firm thickening could be felt. There was no evidence of ulcer scarring and no undue enlargement of the adjoining lymph nodes. No metastatic lesions could be made out in the adjacent structures. In view of the more or less complete obstruction, and since the nature of the pyloric mass could not be determined with certainty by inspection and palpation alone, a subtotal antecolic Polya-type of gastric resection was performed.

Histopathologic Examination—Gross "The specimen consists of the distal portion of the stomach. The serosa is congested. It is difficult to force the small finger through the pylorus. The mucosa of the antrum is coarsely granular and the rugal folds appear hypertrophic. The mucosa of the pylorus is smooth and atrophic. The pyloric muscle measures 2 x 1 cm. On cross-section it appears to be increased in density. The entire wall of the stomach appears thickened.

"Microscopic Examination A—Pylorus The mucosa appears to be somewhat thicker than might normally be expected. Numerous leukocytes are present in the interstitium and some of the glands are separated by this cellular deposit. There are numerous lymphocytes and many plasma cells, occasional eosinophils and polymorphonuclear leukocytes are also seen. There is some increased vascularity in the submucosa. Occasional thick-walled blood vessels are present. The muscularis is converted into a large broad band in which numerous bundles of smooth muscle are

FIG 4



FIG 5

FIG 4—Case 2 Roentgenogram showing extreme narrowing of the pars pylorica. The contour of the stomach at the proximal limit of the narrowed area is smooth and regular. A "fleck" of barium is seen just proximal to the base of the duodenal cap. Note invagination of the base of the duodenal bulb.

FIG 5—Case 2 Roentgenogram taken with compression over the duodenal cap showing in striking fashion the smooth concave deformity in the base of the latter.

present (Fig 6) These muscles have undergone both hypertrophy and hyperplasia Some collagenous connective tissue is present between the muscle bundles

"*B—Antrum* Mucosal changes are revealed which are similar to those described above Occasional small lymphoid follicles are seen in the mucosa The muscularis mucosa is prominent The submucosa shows an increased vascularity The muscularis also seems to have undergone some hypertrophy and hyperplasia, but this is less marked than at the pyloric ring

"*C—Body* Mucosal changes similar to those above described are seen However, there seems to be more edema in the mucosa and somewhat less cellularity The muscularis is also somewhat increased in dimension

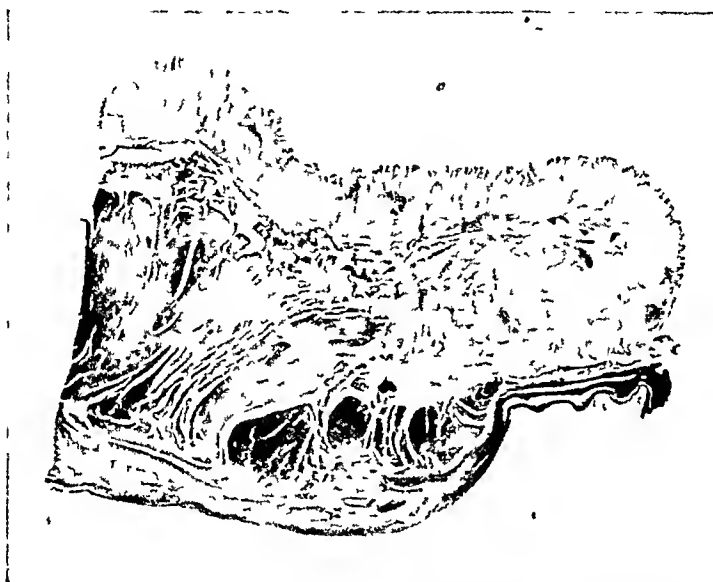


FIG 6—Case 2 Histopathologic section of gastroduodenal junction Note striking difference in thickness of the muscularis between that of the pars pylorica and that of the adjacent duodenum

"*Pathologic Diagnoses* 1 Hypertrophic pyloric stenosis 2 Gastritis, chronic, non-specific 3 Hypertrophy of the muscularis of the antrum, moderate"

Subsequent Course—The postoperative course was entirely uneventful and without complication Fractional gastric analysis, July 7, 1943, disclosed an achlorhydria both to an Ewald meal and to histamine Roentgenologic examination, July 8, 1943, showed no abnormalities in the remnant of the stomach or in the anastomotic area, at the end of three hours only about 10 per cent of the radiopaque meal was still in the stomach Gastroscopic examination, July 17, 1943, showed a patent gastrojejunostomy and mild superficial gastritis involving the mucosa immediately proximal to the stoma The patient remained asymptomatic and was discharged from the hospital, August 7, 1943, after having gained 12 pounds in weight

COMMENT—Hypertrophic pyloric stenosis as it is encountered in infants (Fig 8) exists, as a rule, in the absence of any other organic disease at or near the pylorus The discovery of gastritis or ulcer ought to exclude the diagnosis of simple pyloric muscle hypertrophy as the primary disease Yet, such lesions have been described as associates of simple pyloric muscle hypertrophy in adults In 60 per cent of the 81 cases reported by Kiklin and Harris,² organic lesions of the stomach or duodenum, cholecystitis, or appendiceal disease were found in addition to the pyloric muscle hypertrophy

Although gastroscopic examination prior to operation in both our patients revealed no mucosal abnormalities, chronic gastritis manifested principally by infiltration by plasma and other inflammatory cells, was found on histologic examination of the resected stomachs. The precise relationship between the chronic gastritis and the muscle thickening cannot be stated with certainty. Chronic gastritis may be accompanied by thickening of the pyloric musculature, but this is not often remarkable. On the other hand, the stenosis, particularly the pronounced obstruction seen in Case 2, conceivably, could have resulted

FIG 7



FIG 8

FIG 7—Histologic appearance of normal adult gastroduodenal junction. Note thickness of atrial and pyloric musculature in this area as compared with that in Figures 3 and 6.

FIG 8—Histopathologic appearance of gastroduodenal junction in a child with hypertrophic pyloric stenosis. (Courtesy of Dr. Walter E. Lee.)

in secondary inflammatory changes in the mucosa and submucosa of the stomach at and just proximal to the stenotic area. We feel it justifiable to assume, therefore, that the chronic gastritis found in our cases was not a significant etiologic factor.

From the standpoint of etiology and pathogenesis, the personality pattern that characterized each of our patients is of great importance. Unfortunately, no detailed personality studies were made. The available data, though meager, were, nevertheless, suggestive. Both individuals were aggressive, ambitious, and driving, and both were beset by social and financial problems. When

confronted by distressing situations which would be expected to arouse in any individual a natural reaction of concern and anxiety, both of them were conscious of somatic distress. The pending consummation of a sale or the chagrin and worry occasioned by the responsibility for a wife who was an habitual and inveterate drunkard, are justifiable causes for anxiety in anyone. The fact that both our patients consciously experienced abdominal distress at such times suggests that they were each so constituted that their personality dysfunctioning tended to express itself in a somatic derangement. The latter is further supported by the episode occurring in the period of convalescence of Case 1. He had received several intravenous injections of various types of fluids in the immediate postoperative period. About one week after the last of these he complained of momentary, but severe, twinges of pain in the midsection of his left forearm. He also described a constant burning pain just under the skin in a small circumscribed area around the radial border of the midforearm. The pain was precipitated by motion, complete extension of the elbow, and by pressure in the antecubital fossa. In addition, his arm felt weak and he had no strength in his fist. Thorough examination failed to reveal any objective evidence to indicate an organic nervous lesion and it was the neuropsychiatrist's impression that the pain and weakness were explainable as psychogenic superimpositions. A confident, reassuring manner was adopted and it was pointed out to the patient that his discharge from the hospital could be effected only when the pain and weakness in his arm had completely disappeared. Within a day improvement was apparent, after a few days all pain and distress was gone and the arm was as strong as ever. Proof is lacking, and no certain claim is made, but it is reasonable to hypothecate that prolonged and recurring pylorospasm associated with the personality malfunctionings in each of our patients may have eventuated, at long last, in a fixed hypertrophy and thickening of the pyloric and antral musculature. The validity of this assumption remains to be determined. The existence of a pathogenetic mechanism involving pylorospasm incident to personality dysfunction which, in some cases, may result in a fixed hypertrophy of the pyloric muscle is at least worthy of further consideration. Through the use of extensive personality studies in other such cases, light may be shed on this interesting but insufficiently explored possibility.

Both our patients fall into that group of individuals with hypertrophic pyloric stenosis who, in middle or late life, present a comparatively brief ulcer-like history occurring in conjunction with symptoms and signs of partial to complete pyloric obstruction. In both instances our preoperative considerations favored an obstructing pyloric ulcer, but we were unable to exclude a malignant affection with absolute certainty. Pyloric muscle hypertrophy was considered among the diagnostic possibilities prior to operation, particularly because the narrowed antrum and pylorus with intact mucosa and the invaginated base of the duodenal cap were in keeping with the roentgenographic signs described as distinctive for hypertrophy of the pyloric muscle in adults by Kirklin and Harris.² The condition was dismissed from consideration,

however, not only because we felt that it was exceedingly rare, but also because the roentgenograms showed additional irregularities in the antrum which tended to favor other more common lesions

We elected to perform a subtotal gastric resection in both our cases because of the identification at operation of a pyloric mass, the precise nature of which we could not be certain. In a number of the cases recorded in the literature as instances of hypertrophic pyloric stenosis in adults, the diagnosis was founded merely on the surgeon's observations and was not supported by confirmatory biopsy evidence. In such instances, simple gastro-enterostomy, muscle-splitting, and kindred plastic operations were undertaken. In our opinion, complete reliance for diagnosis on the operative findings alone is a practice fraught with danger. The inability to exclude a malignant growth in these cases justifies, we feel, gastric resection rather than a simple palliative procedure even though one may strongly suspect that the tumor mass is composed only of hypertrophied pyloric muscle.

SUMMARY AND CONCLUSIONS

1 Hypertrophic pyloric stenosis occurs in adults more often than is generally suspected. Two cases seen within a period of two months are reported.

2 The symptom-picture may closely simulate that of peptic ulcer and may develop in middle life without any previous symptoms. Pyloric obstruction of variable degree is a feature.

3 Pyloric muscle hypertrophy in adults may be associated with histologic evidence of chronic gastritis. The exact relationship between the chronic gastritis and the muscle thickening is uncertain.

4 The inability to exclude a malignant growth justifies gastric resection as the procedure of choice.

5 There is suggestive evidence in the two cases reported that prolonged and persistent pylorospasm associated with personality dysfunctioning may have eventuated in hypertrophy of the pyloric musculature.

We are indebted to Major Solomon Weintraub and Captain Joseph Mendeloff for the histopathologic studies, to Major Marston T. Woodruff, Captain John D. Osmond, and Lieutenant Frederick B. Strauss for the roentgenologic examinations, and to Captain Earl Saxe for the neuropsychiatric evaluation of these patients.

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EXPERIENCES IN WAR SURGERY IN CHINA*

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WAR SURGERY must adapt itself to varying conditions and those which prevail in one land may differ from those prevalent in another. Thus, as pointed out by Prof Seymour Baling,¹ conditions which obtained in the wars in South Africa (1899-1902) and Abyssinia (1941-1942) apparently differed sufficiently from those which obtained in fighting in France and Belgium (1914-1918, 1939-1942) as to warrant a more conservative attitude toward wound excision in the former as compared to the more radical attitude adopted for the latter. Nevertheless, much that we have experienced in war surgery on both sides of the lines in several locations in North China (1938-1941) is applicable in a measure to war surgery elsewhere, if not directly, at least indirectly by contrast and comparison.

Preoperative Measures—We have reported the preoperative measures, which we employed, elsewhere^{2, 3}. Briefly, these consisted in intravenous saline and glucose (used with discretion, no blood nor plasma being available), rest, protein-rich diet, ascorbic acid, sulfonamides, specific treatment for intercurrent disease (particularly malaria), and the delimiting tourniquet. The latter consists of a very tight tourniquet applied to an extremity proximal to a gangrenous area where the patient's condition is so grave that amputation is going to be required eventually. Our experience taught us that pre-operative preparation of the patient is very important in war surgery.

Cleansing and Excision of War Wounds—As to the general treatment of war wounds, soap and water early became our mainstay in cleaning up war wounds. We felt it was far more efficient than any other antiseptic, regardless of color. Although a bit messy, this was easily coped with, once our staff got used to it.

In the case of high velocity gunshot wounds, conservatism seemed warranted, particularly in the dry climate of North China. We are inclined to consider the dryness of the climate with its abundance of sunshine as responsible for a probable reduction of the number of pathogenic bacteria in the clothing, on the skin and in the surrounding environment, for similar deductions on this basis have been made by Weddell⁴. We did not excise these wounds, when perforating and uncomplicated, aside from excising the skin about the wounds of entry and exit in some instances. A clean dressing was applied and the part immobilized. Excision of badly contaminated wounds from bombs and the like, however, was done. If seen within 12 hours (and sometimes even after the lapse of as much as 24 hours), the devitalized and contaminated tissues, together with foreign bodies which were readily accessible, were meticulously excised. The wounds did well, particularly if supplemented with sulfonamide in adequate

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dosage by mouth. We started using sulfanilamide tablets in January, 1938, when we received our first consignment of 3000 tablets. Sulfonamide powder, however, was not used locally because it had not become available in sufficient quantity.

If radical treatment is indicated, our experience leads us to say it must be thoroughly radical. Partial excision of devitalized tissue leaves a good culture medium for bacteria to grow in, a principle which is so strongly emphasized by Trieta⁵ and others,⁶ who have had extensive experience in war surgery. Furthermore in doing the excision, it is important that longitudinal and not transverse (except in the case of tense fascia), incision of the extremities be made so as not to cut across nerves, arteries and veins. It is also to be borne in mind that the extremity was probably in a very different position at the time the missile traversed it than the position it is found in as it lies on the operating table. This means that the tract left by the missile is found at different levels in the various muscles and all of these must be sought out if a thorough excision is to be accomplished.

In putting the emphasis on surgery being radical, however, we distinctly do not mean that it is necessarily mutilative. For instance, we saw a fresh gunshot wound in a ten-year-old boy which at first sight seemed to have completely destroyed the elbow joint. Amputation was suggested to us. Radical excision, however, of devitalized tissue followed by proper immobilization resulted in the avoidance of gross infection and the salvage of a functioning elbow joint. Similarly badly infected elbows from gunshot wounds on more than one occasion responded to late excision through a moderately infected operative field and amputation did not become necessary.

Immobilization of the Injured Part—Plaster encasements were used to some extent and we became very enthusiastic over our results with plaster. Our supply of plaster was unfortunately decidedly limited. Nevertheless, in almost every case some form of immobilization for rest of the part was employed. We found the Chinese had good artificers to make Thomas splints which we used considerably, often with Kirschner wire traction. There were also good carpenters who were able to make splints which conformed fairly well to the contour of the part. We frequently found, however, that our cases put up in wooden splints got manipulated by our staff entirely too much, disturbing callus formation and lighting up infection. This is one big reason why we think the plaster encasement should supersede the ordinary splint when possible and we are in accord with Trieta's⁵ general principles of treatment of war wounds with plaster.

Along this line, we might mention a case of gunshot wound with compound fracture of the humerus which proved to be especially intractable. A good result was finally obtained by insertion of Steinmann pins, two in each of the two fragments, followed by incorporation of the pins in plaster after the bone ends had been freshened and approximated.

We had many gunshot wounds which caused compound fracture of the femur. We found that in most of our fractures of the shaft of the femur,

healing took place even when the position of the fragments was not perfect. What we became more concerned about was that there should not be any shortening in the length of the extremity. Kirschner wire traction of the lower fragment of the femur, while the lower extremity lay in a Thomas traction splint with the hinged knee attachment, produced good results in most of these cases.

Hemorrhage from Extremities—One of our complications of gunshot wounds of the extremities was hemorrhage. These cases always called for balanced judgment. Often ligation of a main artery was required. The question, however, as to how other complicating factors affected the issue, usually came up. Immediate ligation sometimes puts in jeopardy the blood supply of an extremity whereas postponement for a few more days, when feasible, insures anastomoses that are more efficient in taking care of impaired circulation.

Several of our cases required ligation, two of the femoral artery and one of the ulnar artery. If seen before infection sets in, it is of course possible to ligate the bleeder in the wound. Our cases were seen late, and in all, the hemorrhage could be controlled temporarily by local compression. Our experience taught us, however, that these patients must be watched as carefully as a patient under an anesthetic, with a tourniquet already on the bed under the extremity ready to be applied. Even then, procrastination cannot be indulged in too liberally lest the patient become exsanguinated.

Again, we encountered hemorrhage in a severely infected knee in our group of 33 casualties referred to elsewhere.³ Maggots may have been responsible for clearing away necrotic tissue from the popliteal space so rapidly that the thrombotic wall in and about the vessels was loosened, although we are aware of this happening frequently in the absence of maggots. We were faced with exhaustion which precluded early operation, hemorrhage which had produced an appreciable anemia and infection of the knee joint which could scarcely be overcome with an impaired blood supply. An attendant stayed by the bed for several days with a tourniquet, ready to apply it promptly on the first indication of hemorrhage. After building the patient up steadily for a week or so, one of our Chinese male nurses gave him some blood and we successfully amputated in the mid thigh.

Amputations—Amputations, unfortunately, were necessary in a number of cases, but the use of sulfonamides did materially lessen the number of cases in which it became necessary to perform them. In our last year we performed approximately 20 amputations out of perhaps a total of about 200 severe war wounds of the extremities which we saw. (This is a rough estimate for our records are in enemy hands and hence unavailable.)

In general, we found that where there was the slightest doubt in our mind as to whether amputation was indicated, it was best not to amputate, as sulfonamides usually turned the scales in favor of the patient in these cases. The question that caused more concern early in our experience was not so much whether to amputate, as when and where, *i e.*, at what level

The latter became more and more clear to us as our experience grew. One of the most important factors in determining this was the type of prosthesis which was available. Fortunately, in our early career in China (1931) we had amputated the leg of a brother of an excellent Chinese carpenter. The carpenter became greatly interested in making wooden legs and the two brothers between them made many ingenious improvements throughout the nine years he was under our observation. The appliance did not equal our modern occidental ones but it was, nevertheless, good and within the financial resources of our patients as well as being obtainable in a blockaded country. The majority of our amputations (as in the above case) were just below the knee and a bent-knee appliance was used. We do not think this is to be recommended where modern appliances are available, but it does serve to emphasize the fact that the amputation site must be adapted to the type of appliance that will be available to the patient later on, as artificial limb makers differ considerably in their ideas and products.

Many of our amputations were of the flap type. We were fortunate in being in a place where we could follow these along. The tightness of closure could be varied according to our conception of whether or not they were likely to become infected. Almost all of them were given sulfanilamide by mouth. As a matter of fact comparatively few of our clean amputations became infected. Obviously this policy of closure cannot be adopted everywhere in war surgery as widely differing circumstances alter the situation tremendously. We did, however, always immobilize and elevate our amputation stumps and we regard this as important.

Fractures of Extremities Due to War Wounds—One of our gunshot wounds of the thigh proved especially unique. Immobilization produced healing apparently *per primam* so far as external appearances were concerned. Roentgenograms, however, showed that the missile, which was still present, had carried with it into the adductor muscles comminuted bone, representing about two inches of the middle portion of the femur together with its periosteum. Traction simply served to exaggerate the gap between the main bone fragments whereas relaxation of traction interposed soft tissue. After an interval of several months, we performed an open operation. The patient objected to a tibial graft. Accordingly, the missile and its satellite bone fragments were excised. The bone ends were then freshened and the bone fragments, which had to be broken up to extract the bullet buried within them, were put back, depositing them between the bone ends. The lower extremity and the pelvis were placed in a plaster spica for several months and firm bony union resulted without too much shortening.

Nonunion was a rather unusual complication of our fractures due to war injuries. The complication most frequently seen was persistent sinus or sinuses due to retained foreign bodies and sequestra. We found that in the type of cases of which we saw most, namely, the casualty that came to us several days after injury, it was usually best to let the fractured bones unite firmly and then go in and operate very radically. For instance,

in a case of gunshot wound of the midthigh with fracture of the femur, the bone was allowed to heal firmly. A persistent narrow sinus to the medial aspect of the thigh remained. Roentgenograms showed large sequestra posterior to the femur. The narrow sinus was slightly widened so as to admit two fingers right down to the bone, carefully avoiding injury to the neighboring vessels. Then a long longitudinal incision was made posterolaterally, exposing the sequestra widely and removing them completely under direct vision. This incision was decidedly radical and was planned so that healing would start from the depths of the wound and take place gradually as packing was extruded. This long wound was packed wide open with vaselined gauze and a wick of vaselined gauze was put into the widened medial opening, following which the part was immobilized. With such treatment we found that most of our extremity wounds healed with no further complication.

Gunshot Wounds of the Pelvis—Gunshot wounds of the pelvis presented a more serious problem. The osteomyelitis that developed here was not so easily treated as that of the extremities. As we look back at these cases we feel that probably our failure lay in not opening up widely, cleaning away sequestra fully, and packing them thoroughly enough. In any case, osteomyelitis of the pelvis presents a serious problem, especially in view of the contiguity of contamination from body excretions and the type of bone involved. In one of our gunshot wounds, the bony sequestra from the pelvis were carried through the bladder into the abdomen and deposited there. Primary suture of the bladder was successful in restoring normal bladder function, but the bony sequestra were not discovered until some weeks later when the omentum which had wrapped itself around them, delivered them at the wound of exit, where it was possible to extract them by a very minor procedure.

Gunshot Wounds of the Abdomen—If there is indication of a penetrating wound of the abdomen, our experience taught us it is really advisable to explore the abdomen promptly, providing one has the time and place available to do it. Often seemingly innocuous wounds of the liver result in fatal hemorrhage which is appreciated too late, while perforations of the intestine must be closed early to avoid continuous peritoneal contamination. Our results in this category were frankly bad. We saw a case of fatal hemorrhage from a gunshot wound of the liver which we believe could have been arrested if we had not adopted the policy of watchful waiting. Our perforated intestine cases, on the other hand, we felt did not do so well partly because we got them too late. Furthermore, we are inclined to feel that in some we wasted too much time in doing a two-layer closure of the bowel. In view of the serious condition of these patients, we are inclined to recommend closure with a single layer of carefully approximated silk or cotton suture.

In one case we failed to find the wound of exit from the stomach, figuring, at the time, that the bullet, which we found lying free in the abdomen had merely penetrated the anterior wall of the stomach through which it had subsequently been extruded, and had not penetrated through both walls

of the stomach. The subsequent clinical course leads us to think that a more careful search by exposure of the posterior wall of the cardiac end of the stomach would doubtless have disclosed a wound of exit. Incidentally, the old rule-of-thumb we found was a good one, namely, that gunshot wounds of the gastro-intestinal tract occur in even numbers, *i e*, one of entrance and one of exit.

Chest Wounds.—As to exploration of chest wounds, the cases we saw in which this might have been done to advantage were seen under conditions where our operating facilities did not warrant it, and this, we think, is an important matter. A chest exploration cannot be undertaken without an expert anesthetist. On the other hand, the sucking wound of the chest, which really may represent a fairly serious situation, we found we could take care of with the simplest of facilities.

Chinese soldiers in civilian clothes had made a raid on the city where we were stationed. The Japanese, in an endeavor to round them up, issued restrictions against any one giving lodging to wounded Chinese. This meant we could not let these casualties come under our roof without incurring the displeasure of the Japanese whose protection we then enjoyed. Well do I remember under these circumstances operating in our front courtyard under the open sky upon a Chinese soldier with one of these sucking wounds from a bayonet stab. We simply injected a little local anesthesia, put in a few silk sutures, strapped the chest tightly with adhesive, and sent the man on his way. He reported later to the clinic as directed, and made a good recovery.

Many of our gunshot wounds of the chest responded to simple rest in bed and sulfonamide by mouth. Unless there was obvious hemorrhage or infection we felt that it was best to leave bullets which had lodged in the lungs or mediastinum strictly alone.

In cases of infection it was usually possible to deal with a well-localized empyema by simple rib resection and drainage. In cases of hemothorax, frequent aspiration should be done as long as blood accumulates so as to remove a potent culture medium. When seen early, we found that auto-transfusion of the aspirated blood was decidedly beneficial, but we would emphasize that there is grave danger of transfusing infected blood after 24 hours have elapsed, and there ought always be a bacteriologic check on it. Sometimes there is no way of stopping hemorrhage aside from exploration and ligation of the bleeder. This should not be delayed too long, particularly when a closure of the chest wall has broken down under the pressure of increasing hemothorax.

Head Wounds.—Ordinary bullet wounds of the head, we usually were able to leave alone without unfortunate results. Roentgenograms ordinarily would show the bullet safely couched in some area of the brain where non-intervention would probably cause less damage than its removal. We encountered one case of middle meningeal artery hemorrhage which we might have saved if we had diagnosed it earlier. The patient had a bullet fired

quite close to his temple and the general contusion of the brain was possibly as great a factor in his rapid demise as the actual hemorrhage

Another of our patients had a severe injury of the head of a rather different type. Banditry was rife in the district surrounding our hospital after the Japanese had taken over the city. Early one morning a bandit came to a farmhouse, where all the members of the household submitted to his demands except the farmer's wife. She was of low mentality and resisted. The bandit picked up the meat cleaver and proceeded to hack away at the vault of her cranium. When she arrived at our hospital, a mass of hair, bones, gray matter and skin presented itself over the left frontoparietal region. Persistent cleansing with soap and water and physiologic saline, cutting and shaving of hair, excision of devitalized skin, removal of bone fragments which had become detached from the pericranium, and cutting away of contaminated and apparently superfluous gray matter, permitted of closure of the scalp. Healing *per primam* followed, and her relatives and friends all insisted that she was greatly improved mentally after our operation!

Sulfonamide Treatment for Erysipelas and Gas Gangrene—Excessive handling, together with improper original toilet because of being seen too late, seemed responsible for the production of erysipelas in some of our burn cases. One of these came down with a fulminating attack of erysipelas which progressed promptly into coma. Five hundred cubic centimeters of a solution of one-half per cent sulfanilamide in physiologic saline was administered intravenously, followed by 200 cc every four to six hours, with most gratifying results.

Similar administration of sulfanilamide was also resorted to in our gas gangrene cases.³ Immediate amputation had been disappointing in our earlier cases. In our later cases, amputation was postponed until after the acute phase had well subsided. In fact, it did not always prove necessary. Despite the fact that we did not have antitoxic serum for gas gangrene available, we succeeded in carrying our last four cases through on sulfanilamide therapy, the first day intravenously and on subsequent days orally, to a successful issue, although on the first two or three days they were very toxic. These cases received no local treatment aside from establishment of drainage in the simplest manner, changes of dressings and immobilization, as indicated. An unfortunate cross-infection into a fresh amputation in the hospital convinced us of the high infectivity of the discharges from these wounds.

Treatment of Tetanus—Tetanus was encountered particularly in badly contaminated cases which did not receive proper early treatment. One case stands out in our mind, of a man who had been reduced by the circumstances of war to scavenging in order to eke out a living for his wife and himself far away from their original home, which the Japanese had burned down at the same time that they had brutally slain their children. Unwittingly he picked up a hand grenade and tried to pry it open. The greater part of his hand was blown off, and he received no treatment until he came to us.

some days later with a necrosing wound. We prescribed hot magnesium sulphate soaks and sodium hypochlorite wet dressings, also giving a prophylactic injection of 3000 international units of tetanus antitoxin. He shortly developed tetanus from which he did not recover. As we look back on this case, amputation in the midforearm might have saved his life even after he developed the first symptoms of tetanus.

Another case of tetanus developed in a Chinese farmer whom, together with all the young men of his village (about 40 in all), the Japanese had captured and bound in a kneeling posture, lined up with his fellow-villagers in a dry river bed. Forty Japanese soldiers took their position along the bank and each one was ordered to fire one shot at his respective target. The soldiers were then told to investigate how successful they had been in killing their targets. Those who had been unsuccessful, picked up large stones from the river bed and bashed in the skulls of their victims. Our patient had a very copious hemorrhage from his right femoral vessels and was thought to be dead. Accordingly he was left. After about two hours, he revived sufficiently to drag himself to his home nearby where he remained until he started to develop symptoms of tetanus. He was then brought to us and we found a suppurating pocketed wound of the thigh. We débrided the wound, i. e. established thorough dependent drainage, removing all foreign bodies and loose necrotic tissue. About 40,000 international units of anti-tetanic serum were given intravenously. He was also given an intraspinal injection of 25 per cent magnesium sulphate (7 cc.) according to the technique outlined by Beckman.⁷ Thorough relaxation was produced to such an extent that respiratory arrest ensued. Calcium chloride intravenously seemed to have little effect in counteracting this, despite Beckman's claim for this as an antidote. Artificial respiration was carried out on him for 16 hours after which he started breathing spontaneously. He experienced no further convulsions and made a full recovery. Trueta's⁵ views on the beneficial effects of immobilization resulting from muscular relaxation in this condition are interesting in the light of this experience. We feel more strongly than ever that elimination of the nidus of infection, even after the development of clinical tetanus, is definitely indicated, although we are aware of disagreement on this subject.⁵

Methods of Anesthesia—As regards methods of anesthesia, we found that the simplest served us best under the circumstances. Local anesthesia with novocain was utilized in many of our minor casualties. Open drop-ether was used extensively. Intravenous evipal was also used in a few instances. Spinal anesthesia and brachial block were employed a great deal, but mostly for cases upon which we were operating a matter of days after injury, where the reaction was favorable. We feel that brachial block and spinal anesthesia in particular are best reserved for cases which are not suffering from shock immediately following war trauma.

Utilization of Roentgenography—As to the use of roentgenography, earlier in the war we had the advantage of obtaining good films, but during the last

year or so, we were working in a place where the Chinese guerillas blew up the electric power plant (December, 1939). Subsequent to this, our electric power was only sufficient for the use of the fluoroscope, and that at only certain times of the day. We got into the habit of tracing the outline of a fluoroscopic shadow on transparent paper superimposed on the screen. We hung up these tracings in the operating room and found them very useful guides as we operated, for usually the pieces of metal or bony sequestra showed up in sharp relief in relation to the intact bone and soft tissues.

Special Surgical Problems—War surgery always is fascinating because each case presents a new problem or combination of problems. Not only is there a multiplicity of missiles, but of the anatomic parts in which they locate and of the directions they take in the human body in its varied contortions. This makes an infinite number of combinations possible. Nevertheless, it seems to be the case everywhere, and our experience was no exception, that wounds of the extremities are decidedly in the majority. Doubtless many of the wounds of other regions are not so generally amenable to treatment and prove fatal even before seen by the surgeon. Then too, it must be realized that the extremities present a large surface area for encountering missiles out of all proportion to their comparative weight.

One of our unique problems was a gunshot wound of the perineum in which the bullet lodged in the lumen of the bulbous and lower membranous urethra. Owing to the contamination of the urethra together with the scorching of the surrounding tissues, it became necessary to open the perineum widely, making the urethra continuous with the rectum as a cloaca. This entire area was permitted to epithelialize. Following a suprapubic drainage, the adjacent rectal mucosa was undermined and brought forward in two lateral portions continuous anteriorly with the urethral mucous membrane. These were sutured together in the midline posteriorly to reconstruct an over-sized bulbous urethra, thereby allowing for subsequent scar-tissue contraction. Then long muscle strips from the two glutei maximi were turned in across the midline to form a new perineal body and anterior anal sphincter. This in turn was covered by redundant upper anterior rectal wall mucous membrane which was freed and brought down so as to suture it in place without tension. A good result was obtained.

Another patient came to us with a fecal fistula of the lower ileum near the cecum, complicated by osteomyelitis of the ilium. This was acquired ten years previously from a gunshot wound in one of China's civil wars. Here, again, we were confronted with some interesting multiple-stage operating. First, the lower ileum proximal to the fistula was anastomosed by side-to-side anastomosis to the transverse colon by aseptic technic to partially divert the fecal current. Then the fistulous area was cleaned-up superficially down to the actual perforation. The fistula was given a chance to heal spontaneously but refused to do so. Finally, the peritoneal cavity was opened up in the region of the fistula and the nearest well-nourished segments of intestine on either side of the fistula were anastomosed

by end-to-end anastomosis after cutting away granulation and redundant tissue. The fistula then healed. The osteomyelitis of the ilium was subsequently attacked and sequestria removed. When last seen, he still had a granulating wound which showed every sign of healing subsequently.

SUMMARY

Our experiences in war surgery in China have been recounted particularly as related to (1) Preoperative preparation of the patient, (2) excision of war wounds, (3) immobilization of the injured part, (4) control of hemorrhage, (5) amputations, (6) war wounds of specific regions—extremities, pelvis, abdomen, chest and head, (7) sulfonamides in erysipelas and gas gangrene, (8) treatment of tetanus, (9) methods of anesthesia, (10) utilization of roentgenography and (11) special surgical problems.

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BRIEF COMMUNICATIONS

MACRODACTYLY*

CASE REPORT

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FOR PURPOSES of interest and record, unusual examples of congenital anomalies are from time to time reported. The following case of macrodactyly, or partial gigantism, affected only one digit. No discernible cause could be found. The child, otherwise, is of normal mental and physical development. There is no family history that would tend to explain its occurrence.

Case Report—M. M., age three, female, was admitted to the First Surgical Division of St. Vincent's Hospital, October 10, 1931. The chief complaint was an enlargement of the right middle finger. The mother stated that at the time of the child's birth, the middle finger of the right hand was much larger and longer than the other fingers of the same hand. She stated that since the time of birth the right middle finger had grown rapidly. This growth was far out of proportion to the child's age and to the other fingers of both hands. Careful questioning elicited no history of any familial tendency or influence to overgrowth. The general past history is irrelevant.

Physical examination showed a well-developed and well-nourished white child, three years of age. She showed no evidence of malformation other than the middle finger of the right hand. The findings, on general physical examination, corresponded with those of any normal child of the same age. Routine laboratory findings were reported as being within normal limits.

Local Condition—The middle finger of the right hand, together with the nail, shows a diffuse, symmetrical hypertrophy of about five times its normal size. This is judged by the corresponding finger of the other hand. There is an abnormal increase of motion of the distal phalanx, which can be easily hyperextended, without pain. There is also an extension of the enlargement running into the palm of the hand superiorly to the thenar eminence. This swelling appears to be the flexor sheath and tendons of the middle finger. The remainder of the digits of both upper and lower extremities are normal.

Roentgenologic Examination—Dr. W. W. Mayer. The right third digit showed abnormal development of the bone structures, without changes in their contour or density other than a broadening of the distal phalanx. *Roentgenologic Diagnosis*
Gigantism.

It was planned to amputate the finger and remove its corresponding metacarpal bone, but the wishes of the mother were acceded to, and a plastic operation was undertaken. The distal phalanx was amputated in order to lessen the length of the finger. Wedge-shaped excisions of soft tissue were performed on either side of the middle and proximal phalanges in order to lessen its circumference. Primary union occurred, but, as was to be expected, the cosmetic and functional result was poor.

The patient was readmitted to the hospital June 23, 1933. Examination showed that the right middle finger, which previously had an amputation of the distal phalanx, was

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MACRODACTYLY

enlarged to about six times its normal size. This enlargement extended on to the palmar surface of the hand. It involved the tendons and sheath of the right middle finger. An amputation of the finger with its corresponding metacarpal bone was performed.

Operative Procedure—A racquet incision was made about the base of the right middle finger. This was extended on to the palm of the hand superiorly to the thenar eminence. Skin flaps were dissected away from the tendon sheath and soft tissues. The sheath and tendons were divided at the transverse annular ligament of the wrist joint and drawn inferiorly. The attachments of the adductor pollicis transversus muscle were separated from the volar surface of the middle metacarpal bone. The lumbrical and interosseous muscles were freed. The volar ligaments from the middle metacarpal



FIG 1 —Photograph of condition preoperatively

bone to the carpus were divided. A one-inch incision was made on the dorsum of the hand over the proximal end of the middle metacarpal bone, and its dorsal attachments to the carpus were severed. The finger, with the corresponding metacarpal bone, flexor tendons and sheath, was then removed. Bleeding points were clamped and ligated. A periosteal suture taken at the distal ends of the second and fourth metacarpal bones, closed the space between them. The skin was united with interrupted silk sutures. A rubber tissue drain was placed in the space between the index and ring fingers. The drain was removed in two days. Primary union occurred.

Pathologic Report—Dr A. Fraser. Sections show signs of abnormal rapidity of growth, both in periosteal and in cartilage replacement bone. The soft tissues show proportional increase in size. Otherwise, the tissues of the finger are normal.

Postoperative Course and Follow-up—The patient had normal function of all fingers except for a temporary limitation of adduction of the thumb. It is assumed that this was due to division of the adductor muscle at its origin on the middle metacarpal bone. Since that time, all motion has returned to a better-functioning and better-appearing hand. The patient, who is right-handed, is now able to use her right hand in writing, eating, playing, etc. She is evidently unmindful of the change brought about.

FIG 2



FIG 3

FIG 2 —Preoperative roentgenogram of both hands for comparative study
FIG 3 —Roentgenologic study of postoperative result

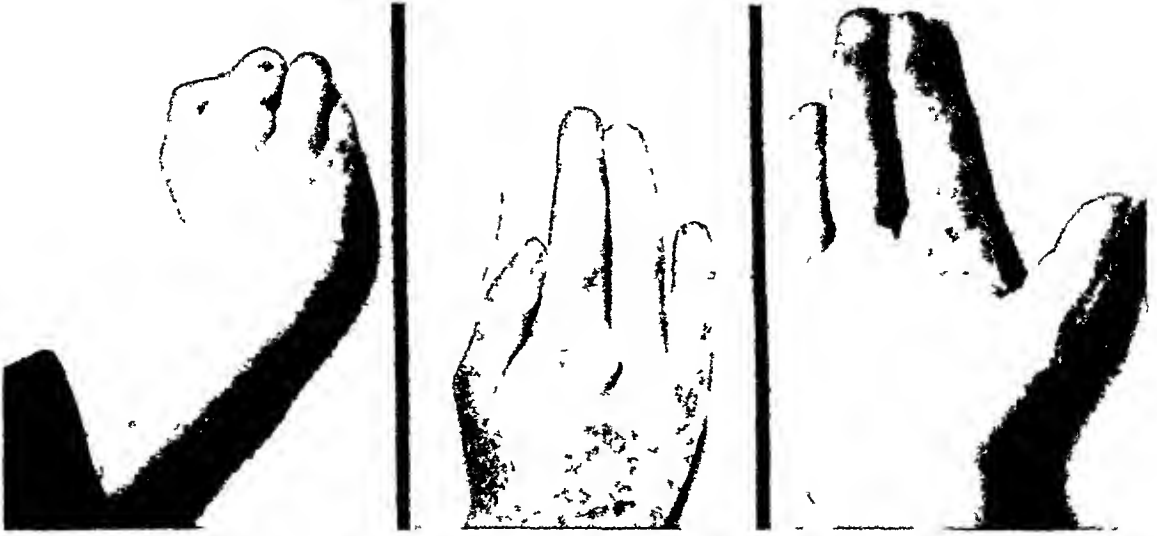


FIG. 4 —Photographs of end result

SUMMARY

Macrodactyly, a congenital anomaly of the hand, affecting only one (right middle) finger is reported. A method of handling this condition so as to give a better-functioning hand, with an improved cosmetic result, is described.

EPIDERMOID (SQUAMOUS EPITHELIAL) BONE CYST OF PHALANX*

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TUMORS involving the bones of the hand are quite rare Coley and Higginbotham¹ found in the material from the Memorial Hospital and the Ruptured and Crippled, in New York, among 1211 bone tumors twenty involving the bones of the hand They reviewed the American and foreign literature up to 1939 and found only 136 such cases The following entities are mentioned—osteogenic sarcoma, endothelioma (Ewing's tumor), giant cell tumor, chondroma, simple bone cyst and metastatic carcinoma

A new type of single neoplastic bone lesion of the hand was first described by Sonntag,² in 1923 Although it is mentioned in several textbooks,³ only ten proven cases of epidermoid cyst of the phalanx have, to our knowledge, been reported This condition has to be considered in the differential diagnosis of every case in which the radiologic examination shows central destructive bone lesion situated in a terminal phalanx of the hand To discuss the pertinent clinical and pathologic features is the purpose of the report of our case

Case Report—A 50-year-old, white, railroad employee injured the tip of his left middle finger one year ago while applying the brakes on a railroad car The finger was very sore for some time, the nail was discolored, but did not come off He did not consult a physician at that time The soreness of the finger disappeared although this finger remained somewhat more sensitive than the others About six months later he injured the same finger again, by pinching it in a drop-door The finger became more sensitive since the second accident, and was periodically red and swollen, especially so three weeks before his admission to the hospital Physical examination showed tenderness, redness and moderate swelling of the soft tissues around the distal phalanx of the left middle finger Pressure was quite painful Motion was normal There was no fever or other systemic symptoms The blood count was normal

Radiologic Examination—Dr J Walton This revealed soft tissue swelling in the region of the distal phalanx of the left middle finger The middle third of the distal phalanx shows a fairly well circumscribed, circular destructive process—revealing an area of translucency which by expansion has broken through the cortex laterally, medially and dorsally but without destruction of the tip or the proximal end of the phalanx (Fig 1)

Operation—Under pentothal sodium anesthesia, the finger nail of the left middle finger was removed A longitudinal incision was then made and the dorsal surface of the bone opened A cystic lining presented itself, which was opened The cyst was filled with sebaceous-like material The whole cyst was easily peeled of its bony bed The bony cavity was then cauterized with electric cautery The further treatment was a modified Orr procedure Vaseline gauze was packed into the cavity and sulfanilamide dusted over the wound, and a plaster encasement applied to the finger The post-operative course was uneventful

* Submitted for publication September 28, 1943

EPIDERMOID BONE CYST

Pathologic Report—Specimen consists of an opened cyst wall measuring on reconstruction about $1 \times 0.8 \times 0.6$ cm. Surface is smooth and glistening white. A good amount of the contents of the cyst, consisting of amorphous, yellowish sebaceous-like material has also been received.

Microscopic Examination—The wall of the cyst is made up by stratified squamous cell epithelium. It consists of a well developed stratum spinosum and a stratum granulosum which is formed by one to two cell layers and a thick horny layer. The latter is obviously forming the dense keratinized contents of the cyst. In several areas a thin layer of fairly vascular connective tissue is found at the outside of the cyst wall (Fig 2).

Since in this case, as well as in all other described cases, no dermal structures (sebaceous glands, hair follicles) were found, the classification of the lesion as epidermoid cyst seems justified.



FIG 1.—Lateral and anteroposterior radiograms of an epidermoid cyst within the terminal phalanx of the left middle finger.

Postoperative Course—Swelling, tenderness and pain have completely disappeared. The fingernail has grown to the end of the finger. The distal phalanx is somewhat shortened. Radiologic examination six months after operation shows the circular translucent area previously reported partially obliterated. The distal portion of the phalanx is now almost in contact with the proximal half and slightly angulated forward due to almost complete obliteration of the pathologic area. There is no apparent union or filling-in of bone in the area (Fig 3).

COMMENT. Epidermoid cyst of the phalanx appears to be a distinct clinical and pathologic entity, as can be seen from the review of the cases in Table I and our own case.

The following is a summary of the most important features. Sex: Eight patients were male, three were females. Age: Two patients were adolescents. The age of the others was between 29 and 50 years.

History. All patients with exception of Cases 5 and 7 gave a definite history of previous injury to the respective finger. The sustained injury was varying

in degree. In several instances it was described as quite serious, in others as slight. The patients with negative histories may also have sustained slight injuries to which they did not pay any attention. The time between first injury and appearance of symptoms varied between 1 and 35 years. In several cases subsequent injury caused, apparently, rupture of the bone tumor with consecutive expansion into the soft tissue.

Symptoms. All patients noticed swelling of the respective fingers. Nine out of 11 experienced pain and tenderness of the finger, especially if the finger was accidentally struck. Five noticed a reddening of the swollen part. No fever or other systemic symptoms were present.

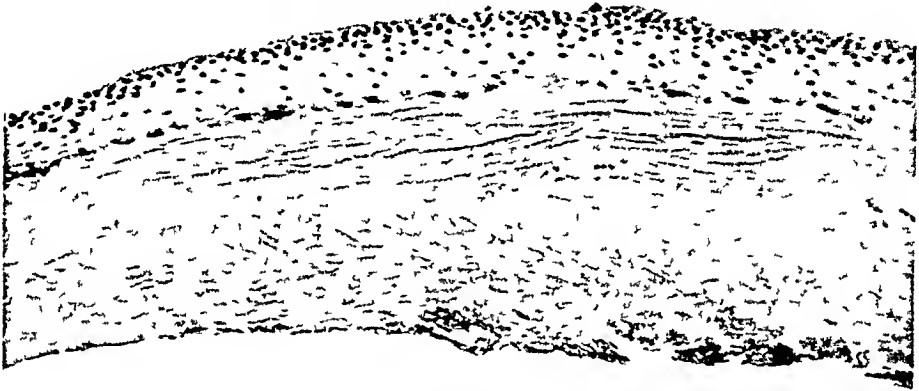


FIG 2.—Section from epidermoid cyst from phalanx ($\times 50$)

Clinical Findings. In ten cases swelling was found at the distal end of one finger, only in Case 1, in which the distal phalanx had been previously amputated, the swelling was found in the end of the stump. There was pain on pressure in the majority of cases. The motion of the finger was not impeded.

Radiologic Examination. The radiograms showed a distinct area of destruction in the terminal phalanx. This translucent area is homogenous, fairly well circumscribed and more or less circular. In one case the cystic area showed irregular vacuolation, in one other case two confluent cysts could be recognized. The lesion is in most cases centrally located. Occasionally it was found nearer to one side of the bone (eccentric). The cortex of the phalanx is frequently expanded. A thin shell of bone may remain or this shell may be completely destroyed in one or more areas, thus leading to pathologic fracture. The lesion is in the majority of cases seen in the distal portion of the terminal phalanx. It occurs, however, also in the middle third or proximal part. It may replace the phalanx entirely. There is no significant periosteal reaction present.

Differential Diagnosis. Since in all cases only a single lesion has been observed, all diseases which lead to multiple bone involvement are easily excluded, e.g., osteitis fibrosa generalisata, multiple myeloma and metastatic carcinoma. The most frequent lesion to cause central bone destruction in a phalanx is enchondroma (Geschickter and Copeland¹² and Jaffe and Lichten-

TABLE I
REPORTS OF EPIDERMOID BONE CYSTS OF PHALANX

No	Author	Age	Sex	History and Clinical Findings	Radiogram	Treatment	Histopathology
1	Sonntag ² (1923)	44	♀	Injured the left hand in a machine crushing the terminal phalanx and the distal part of the middle phalanx of her 4th finger, which was amputated 24 years later. Development of swelling in the stump with pain and increased tenderness upon pressure.	Transparency of the distal half of the remaining middle phalanx	Amputation of middle phalanx	Epithelial cyst
2	Burrows ¹ (1926)	47	♂	At age of 11 ran a piece of wire deeply into his left thumb. 35 years later end of this thumb became swollen. 8 months later a piece of metal fell on this same thumb. Thumb became more swollen, tender and painful.	Irregularly vacuolated cyst occupying nearly completely the terminal phalanx	Amputation of distal phalanx	Contents of the ruptured cyst wall, consisting of white material resembling hydrous wool fat, were found under the skin. The bone was occupied by a single ramifying cyst. The wall of the cyst was formed by fibrous tissue lined by stratified epithelium.
3	Friedlander ⁵ (1930)	13	♂	Injury to left index finger 1 year ago. There was swelling of the finger but no pain.	Expanding cystic lesion with destruction of distal two thirds of terminal phalanx	Amputation of distal phalanx	Smooth cyst filled by sebaceous-like material invested by hornifying epithelium, on one area intermingling granulation tissue containing foreign body giant cells.
4	Hamman ⁶ (1930)	31	♂	Injury to right index finger by hammer blow 16 years ago. Swelling and reddening of this finger and pain whenever finger was struck.	Small, somewhat eccentric, transparent mass destroying the bone in the radial and dorsal side under the nail bed.	Excision of cyst. Complete cure.	Cyst lined by stratified epithelium. Contents partially encrusted by calcium.
5	Harris ⁷ (1930)	Adult	♂	Golf champion. Severe pain and disability of the left thumb 5 years ago. Tenderness persisted and became recently greater and accompanied by swelling. No definite trauma at any time.	Destructive cystic lesion of distal half of terminal phalanx	Excision of cyst	Fibrous cyst wall lined by squamous epithelium
6	Behrens ⁸ (1931)	29	♂	Hand grenade wound in right 5th digit 11 years ago, complete healing, 6 years ago same finger hit by hammer blow. Since then finger became painful, swollen and reddened.	None reported	Amputation of terminal phalanx	Squamous epithelial cyst in phalanx underneath the nail bed
7	Curtis & Owen ⁹ (1933)	29	♂	Swelling and reddening of distal phalanx left third finger with throbbing pain 8 years ago. 4 years later a cyst was excised, with little relief. Distal portion of finger twice of normal size, tender to the touch. No history of definite trauma.	Two confluent cystic lesions destroying all but the base of the distal phalanx	Excision with recurrence. Second excision resulted in permanent cure.	Two cysts found in the partially destroyed terminal phalanx. Cyst wall composed of fibrous tissue lined by squamous epithelium. The cysts contained sebaceous like material.
8	Bissell & Brunschwig ¹⁰ (1937)	Girl	♀	7 years ago injury to finger. Swelling of terminal phalanx.	Rounded well circumscribed, expanding cystic lesion in the proximal half of terminal phalanx	Excision of cyst. Complete filling-in of defect seen in X-ray.	Squamous epithelial lining surrounding laminated keratin
9	Bissell & Brunschwig ¹⁰ (1937)	41	♂	Severe injury to left index finger 10 years ago. Swelling of the terminal portion of the finger, with slight tenderness on pressure.	Expanding cystic lesion replacing all but the base of the terminal phalanx	Excision of cyst	Cyst lined by stratified epithelium containing sebaceous-like material.
10	Yachnin & Sumner ¹¹ (1941)	39	♀	Injury to terminal phalanx of right fourth finger two years previously. Swelling but no redness of the end of the finger for several months, with moderate pain for the last three weeks. 5 months after excision of cyst gradual increase in tenderness but no swelling.	Circular area of destruction in distal part of terminal phalanx, with extension into the periosteum on the radial side.	Excision of cyst. Five months later amputation of distal half of terminal phalanx.	Cyst wall composed of stratified squamous epithelium surrounding a nest of keratin debris.

stein¹³) Trauma is often recalled in connection with the appearance of this tumor, but not a trauma dating back such a long time as frequently observed in epidermoid cyst. Swelling and pain are mostly moderate. Radiograms may show a very similar appearance to that found in epidermoid cyst, however, trabeculation of the cystic space with small areas of increased density are frequently seen.

Simple bone cysts are very rare in the phalanx. Jaffe and Lichtenstein,¹⁴ in a recent publication doubt whether they ever occur in the bones of the hand or feet, although single instances in this location have been reported. They occur nearly always before the age of 20. They usually cause no symptoms before fracture occurs. The radiogram shows, as a rule, no, or only little, trabeculation in the cystic area. The third cystic bone lesion

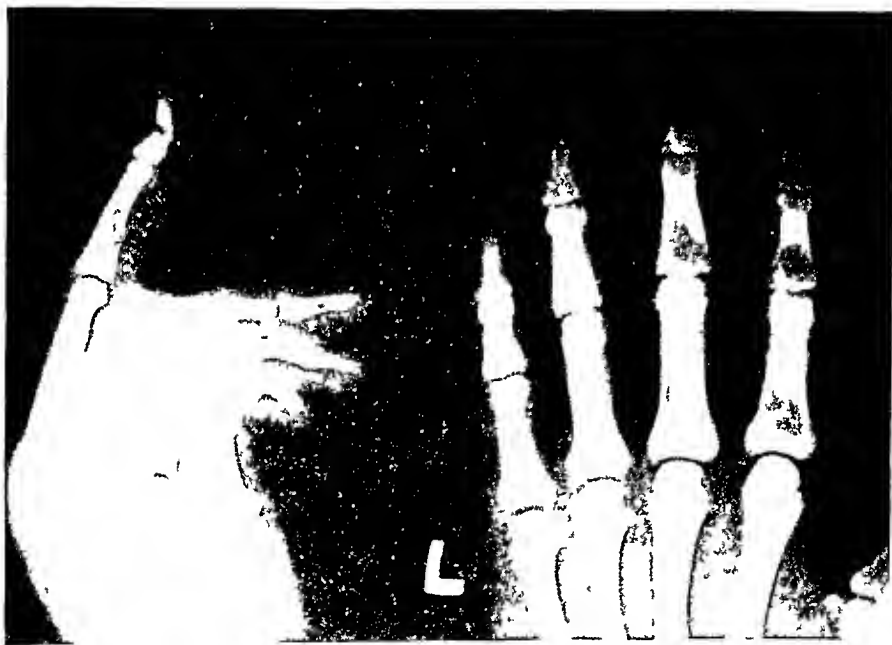


FIG 3—Lateral and anteroposterior radiograms six months after excision of an epidermoid cyst

—giant cell tumor—is also very rare in the phalanx of the hand, somewhat more frequent in the metacarpal bones. It occurs mostly in the 3rd decade of life. Trauma is usually recalled. The tumor develops fairly rapidly, causing distinct discomfort. The history is usually fairly short. The radiogram shows the area of bone destruction traversed by fine trabecules.

Osteogenic sarcoma and endothelioma (Ewing's tumor) are extremely rare in the phalanges of the hand. Their radiologic appearance varies so markedly from the central cystic lesion of epidermoid cyst without periosteal reaction that the differentiation should not offer much difficulty.

Inflammatory lesions rarely produce a picture that imitates the epidermoid cyst of the phalanx. Brodie's abscess, a form of chronic osteomyelitis, occurs usually in the tibia, showing quite distinct thickening of the bone around the cystic area. A bone gumma is rarely found in a phalanx. Periosteal reaction

is usually quite prominent. If any doubt exists, history and Wassermann reaction will be of great help.

In the differential diagnosis endochondroma has, therefore, to be considered primarily. Simple bone cyst and giant cell tumor have also to be taken into consideration. If the decision cannot be made on the basis of radiographic and clinical findings, the diagnosis can be made at operation without difficulty, since the appearance of the white, glistening cyst wall filled with sebaceous-like material is absolutely characteristic.

Therapeutic Procedure In four cases the phalanx containing the cyst was amputated. In six cases the cyst was excised. In two of these cases recurrence occurred after removal. In one case the second excision led to complete cure, in the other case the distal part of the phalanx was removed, with good result. It seems that our procedure to open the bone, remove the cyst, and then to cauterize the bony cavity carefully is of definite advantage. It preserves the finger and prevents possible recurrence of the tumor.

Etiology The etiology of this tumor has been recently discussed by Yachnin and Summerill¹¹. The cysts resemble the implantation cysts that have been found in the soft tissues of the finger and hand, especially in tailors and seamstresses. Two different theories concerning their etiology are found in the literature: (1) Congenital maldevelopment, with embryonal misplacement of epithelial cells, or (2) traumatic implantation of epithelial cells into deeper structures. Experimental work supports this latter view. It is quite probable that the epidermoid cysts in bone are also caused by implantation of epithelial cells. In some cases (Behrens⁸) the continuation of epithelial cells from the injured skin into the bone could be seen microscopically. The implantation of epithelial cells into the bone may occur through a very small fracture or by transmission along the vascular channels (Yachnin and Summerill¹¹).

SUMMARY

A case of epidermoid cyst within a phalanx is reported. The clinical, radiologic and pathologic findings of the cases hitherto described in the literature are summarized, and the differential diagnosis of this tumor of the bone is discussed. Treatment by excision with following electric cauterization is recommended.

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PRESACRAL DERMOID*

CASE REPORT

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AS A RESULT of the physical examinations incident to the mobilization of large numbers of individuals for war and industry, there has been a renewed interest in the various congenital defects to which we find ourselves heir. Of these, various involvements of the sacral region are frequently found. Simple pilonidal sinuses have been observed in two to five per cent of young adult males,⁶ but their incidence is much lower in females. However, there is a congenital anomaly of the sacral region which has been described as occurring only in females. This is the presacral dermoid.

The incidence of these tumors is quite rare. Whittaker and Pemberton⁷ were able to find nine cases at the Mayo Clinic. They state an incidence of ventral tumors of all types of one in 40,000 registrations, and from their statistics Manheim, Druckerman, and Peskin³ computed only one dermoid cyst in 97,000 registrations. Lahey and Eckerson² report three cases from the records of the Lahey Clinic. All cases reported were in females. Manheim, Druckerman, and Peskin report one case from Mt Sinai Hospital, which was the only known case at that institution.

The derivation of this tumor, as that of the other tumors, which involve the complex embryonal process of the caudal extremity, is obscure. The dermoid tumor is of necessity ectodermal in origin, and those ventral to the sacrum may arise possibly from either of three structures: (1) Proctodeal membrane, (2) postanal gut, and (3) vestiges of the neurenteric canal.

(1) *The proctodeal membrane* is usually the origin of tumors of the pelvic connective tissue or nodules of the penis or scrotum.

(2) *Postanal Gut*—This is the terminal portion of the hind gut which is "pinched off" following the union of the protodeum and the hind gut at a slightly higher level. This portion usually atrophies but may be the origin of classical cystic tumors between the coccyx and the rectum described by Middeldorpf,⁴ and later bearing his name. This tumor contains an isolated, convoluted, portion of intestine surrounded by fat.

(3) *Vestiges of the Neurenteric Canal*—It is from this source that it would seem most likely that a simple presacral dermoid would develop. It is generally agreed that they arise from a portion of ectoderm that is separated during a faulty coalescence or invagination of a portion that failed to atrophy.

The simple dermoid, as found in this region as well as in other parts of the body, represents one of the simpler forms of cystic tumors, the wall of which is composed of the epidermis, derma and their structures. They contain

* Case studied while attached to Station Hospital, Fort Oglethorpe, Ga. Submitted for publication September 4, 1943.

a thick, often foul smelling sebaceous material and frequently hair. They may be single or multilocular.

Occurring in the coccygeal and presacral regions are the related and more complex neoplasms from which the simple dermoid must be differentiated. These include the chordomata, whose histologic appearance is that of the primitive notochord, and teratomata comprising the three embryonic germ layers. The latter is a large group in which most writers place poorly defined and differentiated tumors comprising two or more types of tissue. These



FIG 1.—Lateral roentgenograms following barium enema. Anterior border of the tumor has been outlined on the film. (All photographs are by the Army Signal Corps.)

tumors are most commonly seen in infants. Of these, one-third are born dead, and 90 per cent of the remainder die during the first few days of life.¹ Very rarely we find other types of tumors arising from the bone, cartilage or other connective tissues. Walker and Pemberton⁷ report a fibrosarcoma, a chondromyxosarcoma, and a fibroma in their series.

Case Report—No 81736. A. H., white, female, age 21, a W. A. C. auxiliary, was admitted to the Station Hospital, Fort Oglethorpe, Ga., April 23, 1943. She had had no complaint but was referred because of a mass found in the pelvis at routine examination. She had had no operations or serious illnesses. She had never suffered from constipation.

Physical Examination—The patient was a tall, thin individual. Weight 120 pounds. Height five feet eight inches. Her general examination revealed no abnormality except

that found in the pelvis. There was a slight vaginal discharge. The cervix was normal to palpation. The uterus was normal size and position. A speculum could not be inserted due to a mass the size of a small grapefruit, which bulged into the posterior vagina. By rectal examination it was determined that this mass lay posterior to that structure. The mass itself was not tender and was cystic, having a soft mushy consistence. There were no abnormalities of the coccygeal or anal region.

By proctoscopic examination the mucosa overlaying the mass had a normal appearance. It was felt by the examiner that the instrument could not safely be passed by the cyst. Under novocain anesthesia, a needle was inserted posteriorly into the mass and, with difficulty, one cc of thick white fluid was removed. This had a milky appearance and proved to be sterile when cultured.



FIG 2—Operation showing part of cyst wall

Roentgenologic findings "With the rectum filled with barium, a soft tissue mass, about the size of a grapefruit, is seen to displace the lower rectum anteriorly and slightly to the left."

Operation Under spinal pontocaine (20 mg) anesthesia, a midline posterior six cm-incision was made.⁵ The coccyx was removed by separation of the sacrococcygeal ligaments. A large cyst, 10 x 12 cm, was easily exposed. The muscles overlying the cyst were poorly developed. The dorsal surface of the tumor was free but it was attached on the lateral surfaces and apparently inferiorly. It was seen by the operator that it could not be removed intact. Blunt dissection was continued until it ruptured and released about 200 cc of thick, foul smelling material with large cheesy lumps and flakes. A finger was inserted into the sac and six to eight other similar but smaller cysts were identified. The cyst was not symmetrical and several small protruding pockets were identified. The dissection was then continued much in the manner that a hernial sac is stripped. The peritoneum lay superior to the mass and was not entered. On the ventral surface the rectal wall was practically continuous with the cyst. Inferiorly,

the sphincter ani internus was identified. Dissection from the rectum was facilitated by the injection of saline beneath the lining membrane of the cyst. By using this procedure bleeding was kept at a minimum. An assistant inserted his finger into the rectum and it seemed that the rectal wall was even thinner than normal. The cyst having been opened it was necessary to remove it and the smaller cysts piecemeal. Examination of the tumor disclosed no solid portions, teeth, bone or hair and one cyst, approximately 1 cm in diameter, was sent for microscopic examination. Five Gm of sulfanilamide were inserted in the wound. Interrupted silk was used to close the wound. The defect could not be completely closed and a small rubber tissue drain was inserted.

Pathologic Examination—Gross "Specimen consists of an irregular fragment of membranous tissue in which there is a cyst about 1 cm in diameter, filled with thick coffee-colored material. *Microscopically*, the cyst is lined with stratified epithelium. No inflammatory reaction is present." *Pathologic Diagnosis* Epithelial cyst.

With the exception of moderate difficulty in voiding and headache, her postoperative course was good. Wound dressed on 4th postoperative day and rubber tissue drain partially withdrawn, with release of 2 cc of old blood. Three days later drain entirely removed. In all dressings care was exercised to isolate the wound from the anus. Surface of wound was dusted with sulfanilamide powder. Skin sutures were allowed to remain to the 10th postoperative day. With dressings the finger was inserted in the rectum and the site of removal was gently pressed to remove the collected fluid. The area soon decreased in size, and had the feel of the prostate gland. This rapidly disappeared and the wound was entirely healed on the 19th day, at which time she was discharged from the hospital. She was seen again one month later and had no complaints. The wound is healed and she is carrying out her duties in the W A C.

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BOOK REVIEW

GASTRO-ENTEROLOGY By Harry L. Bockus, M.D. Volume I W. B. Saunders Company, Philadelphia, 1943

To make possible the publication of a medical book of such perfection as is exhibited in the First Volume of the proposed three volume textbook on Gastro-enterology, by Bockus, is an effort of which all concerned may be proud but for the Saunders Company to accomplish this during the chaotic times through which we are passing would seem to be making possible the impossible.

The usual quality of the paper type and binding together with that of the illustrations and the generous use of beautiful color attracts the reader at once and inveigles him into making the attempt to assimilate this exhaustive, but not exhausting, presentation of a rapidly developing specialty.

To the lay public—at least—has come an appreciation of the fact that the civilian population, as well as the Army, "lives upon its stomach," and this presentation should appear as timely to the younger members of the medical, and even to the surgical professions.

Among the many unique features of this effort is the abandonment of the present day plan of engaging large groups of authors, from many sources, for the preparation of symposia instead of the one-man authorship of textbooks as in former times.

Bockus states that his collaborators have been his associates in a group who have been working together for many years in a teaching institution—The Gastro-enterological Department of the Graduate School of Medicine of the University of Pennsylvania, and as a result he believes they have developed an unusually broad interest in both medicine and gastro-enterology.

To the reviewers this attitude seems to have made possible a unity and directness of presentation of these two divisions of medicine which are usually lacking in modern medical textbooks.

Volume I deals with the Esophagus and the Stomach, devoting more than 300 pages to the problem of Peptic Ulcer.

Volume II will be concerned with the Small and Large Intestine and the Peritoneum.

Volume III will cover the subjects of the Liver, Biliary Tract, Pancreas and Secondary Gastro-intestinal Disorders.

A separate Desk Index Volume is evidence of the meticulous planning of the author which is apparent on every page of the first volume.

WALTER ESTEIL LEE, M.D.

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A REPORT ON THE MANAGEMENT OF BURNS

USING THE OCCLUSIVE COMPRESSION DRESSING, WITH SULFATHIAZOLE EMULSION

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IN THE NOVEMBER, 1942, number of the ANNALS OF SURGERY, the authors¹ reviewed the problem of the treatment of burns and set forth their conception of the principles upon which this should be based, the essence of the matter being that a burn is a large wound and should be treated as such. They, furthermore, suggested that fundamentally all treatment should be timed to anticipate the dangers and difficulties arising from severe burns, namely shock, toxemia and infection, with their sequelae of death or disability. From this broad conception of the problem they evolved a system or method of treatment divided into general and local measures. This plan was based upon a practical timing chart which was intended to be a ready reference to all doctors and nurses handling burns. In selecting the measures for treatment they attempted to embrace the best methods of dealing with the problem having due regard for (a) fundamental surgical practice in the treatment of all wounds, and (b) the experience of others with practical knowledge of the problem. The details of the plan and principles are reviewed briefly in the following schema.

TIMING IN THE TREATMENT OF BURNS (see operational chart)

General Measures To anticipate and prevent shock, toxemia and infection —with death, sepsis and inanition

- 1 Retention of body heat by a burn tent or other measure
- 2 Prevention of pain by adequate sedation
- 3 Control of hemoconcentration and other blood changes by the regulated use of blood, plasma, serum, etc
- 4 Controlled administration of fluids and the necessary amount of carbohydrate and protein food either by infusion or by mouth
- 5 Specific antisera such as antitetanic and antigas
- 6 Gentle handling to avoid pain and fatigue
- 7 Delay in carrying out any local treatment until antishock measures are at least well advanced, and control in view. This rule is operative in the

treatment of all wounds. If necessary, local treatment already commenced should be interrupted if signs of shock recur.

8 Avoidance of anesthetics whenever possible to prevent further shock and depression of general condition.

9 Promotion of renal output by adequate fluids administered by vein or mouth.

Local Measures. To anticipate and prevent infection and maiming, with disability or death, and, conversely, to promote rapid healing.

1 Gentle surgical wound cleansing with soap and water, saline and, when necessary, some other detergent.

2 Removal of débris, and surgical excision of dead and devitalized tissues. This includes the opening of blebs.

3 Employment of occlusive bulky pressure dressings, infrequently changed, to promote

(a) Rest by immobilization, resulting in lymphstasis.

(b) Prevention of bacterial contamination by exclusion.

(c) Pressure (1) to prevent edema and thereby improve the circulation of the blood, (2) to minimize the lymphatic flow.

(d) Drainage into the bulky absorptive dressing of discharge from the burned surface.

(e) Bacteriostasis 1 Autogenous 2 Bacteriostatic sulfonamides,* etc.

4 Employment of the earliest possible skin grafting.

(a) Primary, when possible, though rarely practicable.

(b) Delayed primary as the common practice.

(c) Secondary when made necessary by very deep and extensive burns or by delay for some special reason.

(d) Homografts when necessary to save life or minimize inanition.

The authors have completed a review of two years experience with well over 200 major and minor burns treated according to the plan outlined. From this group of cases, 100 major burns, requiring hospitalization, have been selected for particular analysis. The remainder, mainly treated in the out-patient department, require only the statement that they have shown equally satisfactory results under less adequate control. Incidentally, a considerable number of frost-bites were treated with similar success by this method. For detailed study of the major burns treated in hospital and to make the analysis more comprehensive, they have been broken down for study into three groups as follows:

Group (A)—According to area of body surface involved.

Group (B)—According to the depth of the burn.

Group (C)—According to the results of treatment.

For simplicity's sake Groups A and B will be dealt with rather briefly, leaving C for more detailed analysis.

* A five per cent oil-in-water emulsion of sulfathiazole (M. G. H. formula¹) has been used almost exclusively for this series.

GROUP (A)—BREAKDOWN ACCORDING TO AREA OF BODY SURFACE BURNED

Ten per cent of Body Surface Twenty of them were 10 per cent or under, but are included for certain specific reasons, *e g* (a) Their particular location involving hands, genitals and face, and (b) because they had a pre-existing infection before being treated by this method

Ten to twenty per cent—There were 40 cases in this group, included for the following reasons

- (a) Some were serious burn problems, and there was one death, an infant in shock
- (b) Some were skin-grafted
- (c) Some were representative of a group of superficial burns, showing rapid exit from hospital under adequate treatment

Twenty to thirty per cent—There were 26 cases in this group. All were severe burn problems requiring antishock measures, and several were grafting problems. *There were no deaths*

Thirty to forty per cent—There were ten cases in this group. All suffered severely from shock and to some extent from toxemia. There were three deaths: (1) A case complicated by steam inhalation, with respiratory congestion and pulmonary edema. This case died 11 hours after admission, (2) a child of three, died from toxemia on the third day, and (3) a nine-year-old child who died in 12 hours from shock and asphyxia

Forty to fifty per cent—There was one case in this group. This case died from toxemia

Fifty per cent and over—There were three cases in this group—two of them were 80 per cent burns. Both died—one from shock, and one from inanition, with severe psychosis. The third patient, with about a 60 per cent burn, is living and well

GROUP (B)—BREAKDOWN ACCORDING TO DEPTH OF BURN

In discussing this series of burns according to their depth we submit our working classification, with comments. Burned skin reepidermizes (heals) from the following sources of epithelium: 1 Margin of the wound 2 Viable epithelium remaining on the surface 3 Hair follicles and sebaceous glands 4 Sweat gland ducts

The propensity for healing (reepidermization) of burned skin will depend upon the number of available sources of epithelium for regeneration

Number 1 is always available but, of itself, in all but burns of small area, is insufficient for good results

Numbers 1, 2, 3 and 4 are all available only in superficial burns

Numbers 1, 3 and 4 are available in burns which destroy the epidermis but do not extend deep enough to destroy the hair follicles

Numbers 1 and 4 only are available when destruction extends beyond the depth of the hair follicles but does not reach the sweat glands

Number 1 only is available if there is full-skin destruction, or deeper

In the average burn Numbers 3 and 4 (hair follicles and sweat gland

ducts) play a very important rôle and, since these structures vary greatly in number and depth of location in the skin in different parts of the body, so the available sources of regeneration of epidermis will vary with the locality involved

If both hair follicles and sweat gland ducts are available reepidermization, under optimum conditions of treatment, will probably be rapid and satisfactory

If sweat gland ducts alone are available, reepidermization will be very slow and, by the time it is complete, there would have developed abundant granulation tissue with organization into fibrous tissue and an end-result of scar skin. Exceptions are the palm and sole, where sweat glands are very numerous and hair follicles lacking

Superficial burns with blister formation are easily recognized. So, also, are burns which destroy the skin completely. But, in burns in which the skin is partially destroyed beyond the depth of the superficial ones, it is usually impossible, on first observation, to be certain to what depth destruction has extended. Moreover, our examination of biopsies from many burns reveals a great deal of variation in depth of destruction so that it is impossible to be certain how much epithelium has been spared for available sources of reepidermization

For the above reasons one must let time decide whether spontaneous healing will occur, or whether it will not, and skin grafting be required. Essentially, burns may be divided into the two classes (1) Those that reepidermize spontaneously and rapidly enough to give good results, and (2) those that will not reepidermize rapidly enough, or at all, and will require grafting

Since there are two obvious degrees of burns, the superficial and deep and a less obvious intermediate degree of uncertain depth, we would suggest that for classifying burns at the time of the accident, three degrees only need be used, *i e*, superficial, intermediate and deep. Time will split the intermediate class into two divisions—those that heal spontaneously and well, and those that do not

Ultimately, by the aid of time, we may then for purposes of record include four degrees in our classification

- 1 Superficial (down to level of papillae, usually forms blisters)
- 2 Superficial-intermediate (from papillary zone to a level just below sebaceous gland and sparing the lower end of hair follicles)
- 3 Deep-intermediate (below No 2 and to a level above the sweat glands, in which most of the hair follicles have been destroyed)
- 4 Deep (from the level of the sweat glands down)

In the classification herein presented, Groups 1 and 2 healed spontaneously and Groups 3 and 4 required skin grafting

Many cases in Group 3 might have ultimately healed, but the process would have been long delayed, exposing the patient to the hazards of granulating surfaces over a long period of time and, at the best, healing by scar skin

Our criteria for the divisions of the intermediate degrees is whether or not reepidermization is well advanced at the end of 14-21 days. *In the last analysis, and from a practical surgical viewpoint, every case of burn that requires dressing falls into one of two groups—those that heal spontaneously and satisfactorily, and those that do not, and should be skin grafted*

In this series 17 of the cases required skin grafting, including one which eventually died

Exclusive of the remaining six deaths, there were then 77 cases which healed without grafting

Of the 17 cases that required grafting, there were four cases of full-skin thickness, or deeper, which would be classed as 4th degree, or deep, and 13 cases of partial destruction in which reepidermization was absent or would have been retarded to such a degree that healing would have occurred only by scar skin and consequent disability and prolonged hospitalization or potential fatality from exhaustion. These cases fall into our third degree or deep-intermediate

Of the balance of 77 cases that healed spontaneously, 57 cases were easily recognizable first degree, or superficial, burns, and healed within 14 days. The remaining 20 cases fell into Group 2, or superficial-intermediate, and required an average of 22 days to heal, varying from 15-42 days

GROUP (C)—BREAKDOWN ACCORDING TO RESULTS OF TREATMENT

GROSS STATISTICS

	No. of Cases
1 Deaths	7
2 Deep burns grafted	16
3 Deep burns not grafted (patchy areas in burns over 10%)	6
4 Superficial burns of 10% and over with delay in treatment of from 1-10 days and consequent preexisting infection. Treated by a single dressing. Average time before removal of dressing 9 days. Average days in hospital, 11	22
5 Fresh superficial burns without delay in treatment, 15%-30% in area. Treated by a single dressing. Average time before removal of dressing 8 days. Average days in hospital 10	35
6 Miscellaneous cases (burns of special areas)	14
Total	100

I DEATHS

Case 1—No 5403-43. A 47-year-old male, with a fire burn of 80 per cent of the trunk, extremities, head, face, etc. On admission shock was very marked, with a Hb of 130. He received 1,000 cc plasma and 2,000 cc glucose 5 per cent—Shock was not controlled. He died still in shock and coma at 16 hours. He received 1 cc precortin intramuscularly.

Case 2—No 4402-43. A nine-year-old male had a 30 per cent burn caused by hot cinders. On admission shock was moderate (Hb 100, B P 80/60). He received 750 cc of plasma and 450 cc 5 per cent glucose solution, but rapidly became comatose and died in 11 hours.

Case 3—No 8188-42. A three-year-old male child had a 30 per cent scald burn from hot water. His admission was delayed for over two hours. Shock was severe (Hb 107, B P 110/70). He received 1500 cc of plasma and 1500 cc of glucose-saline. He recovered from shock and his condition was quite satisfactory at 24 hours. At about 28 hours, however, he developed toxic signs with vomiting, coma and urinary suppression. He died within 50 hours from toxemia.

Case 4—No 5328-42 A six-months-old male child, with a fire burn of 18-20 per cent from a celluloid toy, involving face, arm, forearm, hand and neck. He was admitted in marked shock and was given 500 cc plasma plus 500 cc normal saline. He died at 36 hours, after being apparently in fair condition with shock controlled. A few hours before death he developed edema of face, extremities, etc. Suppression of urine was followed by collapse, vomiting and coma. Death was apparently from toxemia. It should be noted that there was some delay in treatment. The patient was more than an hour *en route* to the hospital, and a further half hour elapsed before plasma was administered.

Case 5—No 965-43 A 47-year-old female, with a fire burn of over 40 per cent, who died on the ninth day in coma with suppression of urine. She had had hemaglobinemia continuously from the fourth day. Admission shock was severe but controlled (B P 160/80, Hb 114). The cause of death was not clear. The only pathologic feature, other than the burn, noted at autopsy was extensive edema of liver, kidneys and lungs. She received 3,000 cc plasma, 2,000 cc of whole fresh blood, 9,000 cc glucose 5 and 10 per cent, and 1,000 cc saline. Cortin was given intramuscularly and intravenously, but only after 48 hours.

Case 6—No 1625-43 An adult male of about 30 years, with a 35 per cent steam burn involving face, neck, head, trunk, arms, hands. It was complicated by the inhalation of steam and the patient required tracheotomy for edema of respiratory passages. Shock was marked (Hb 118, B P 210/110). He received 1,000 cc plasma. He died 11 hours after admission, still in shock but complicated by asphyxia from edema of the lungs.

Case 7—No 2473-43 A 24-year-old male who had an 80 per cent electric burn. He had been treated for 6 weeks at Avida with compression dressings and sulfathiazole emulsion. He was transferred in a state of toxic psychosis, and refused all food. His general condition was improved with blood transfusions and intravenous therapy. He received two graftings which both took well but he died after four weeks from inanition.

RÉSUMÉ OF DEATHS

Case	Cause of Death	Area	Time of Death
1	Shock	80%	16 hours
2	Shock	30%	12 hours
3	Toxemia	30%	50 hours
4	Toxemia	18%	36 hours
5	Toxemia delayed	45%	9 days
6	Pulmonary congestion and asphyxia	35%	11 hours
7	Inanition	80%	90 days

2 DEEP BURNS GRAFTED

In this series of 100 major burns treated by sulfathiazole occlusive pressure dressings, 26 skin grafting operations were performed on the 16 patients requiring grafting. The grafts were all of the delayed primary or late primary type. The cases, with significant comments, follow.

Case 1—No 6780-43 A 35 per cent scald in a 14-month-old female, with wide blisters and intervening white, leathery areas. Severe shock. Placed in sulfathiazole occlusive dressing within four hours of burn. Excellent recovery. First redressing on 16th day, when superficial burns were healed and the obviously sloughed areas were surgically debrided and grafted with one dermatone sheet from opposite side of the abdomen. Second redressing on 26th day, removal of sutures, 100 per cent graft take. Completely healed and discharged 30th day.

Comment The ideal case. First redressing and grafting could have been undertaken on the 12th to 14th day.

Case 2—No 4736-43 Circumscribed deep burn, 8 x 6 inches, of thigh in adult male, when motor car engine was pushed against thigh in an accident Sent in for grafting about the 35th day Placed in occlusive sulfathiazole dressing and grafted four days later, with complete take Discharged 14th day with complete healing

Comment This type of case might have had a primary graft immediately following injury and would have been in hospital 14 days only, with complete healing Thirty-five days were wasted

Case 3—No 7706-43 A four-year-old male was burned on left calf by a hot radiator Sulfathiazole emulsion dressings as an out-patient for one month, then admitted for grafting Area 4 x 4 inches grafted with skin from same thigh, 0.10 inches thick Redressing in 13 days—complete take

Comment Might have had a primary graft immediately or a delayed primary graft at first redressing The outdoor treatment should have been dispensed with

Case 4—Severe 12 per cent scald in three-year-old male, blisters and white, leathery areas over scapula and left arm Admitted and placed in occlusive sulfathiazole dressing within four hours Anxious parents refused to allow child to remain in hospital, and was treated with questionable dressing technics at home Readmitted for grafting on 36th day Grafted with back skin 0.10 inches thick on 40th day First redressing 51st day, poor 20 per cent graft take (shoulder movement?) Regrafting was 100 per cent successful

Comment A poorly managed case

Case 5—No 72-43 Scald, 12 per cent, in 15-month-old male child of left arm and forearm, midchest, right elbow, left abdomen and left thigh Immediate sulfathiazole occlusive pressure dressing Redressed seventh and 13th days, third redressing on 21st day, when all other areas were healed but thigh and abdomen, which were grafted with 0.08 skin from outer aspect of left thigh, fourth redressing 29th day, with 100 per cent graft take

Comment Too many redressings—should have been grafted earlier

Case 6—No 7506-42 Deep, gasoline 20 per cent fire burn of whole left leg and buttock Received on the 12th week, with some triple dye still adherent, infected granulations, and patient in state of inanition and low morale Sulfathiazole pressure dressing routine Five redressings and graftings in 70 days, blood transfusions twice weekly and at operation Eight weeks convalescence with complete healing and no disability

Comment An excellent lesson in delay from eschar This case should have been begun in the third week All the grafting would now have been done in three operations, with two surgical teams each time

Case 7—No 3309-42 Deep 20 per cent burn in 70-year-old male who was burning rubbish when paint and benzene content exploded Grafted at third redressing on 28th day to left forearm and elbow, complete circumference Three successive graftings completed by the 45th day

Comment Grafting should have been started earlier and completed in two operative stages

Case 8—No 2420-42 Scald, 10 per cent, of back of thigh in five-year-old male, of which 5 per cent was a deep burn. Treated in the outdoor for three weeks and admitted for grafting. Grafted after five days sulfathiazole pressure dressing routine with 28-square inch of skin 010 of an inch thick from the midback region. Second redressing 14 days later with complete take.

Comment The outdoor treatment should have been dispensed with and the grafting undertaken earlier.

Case 9—No 8122-42 Scald, 20 per cent of chest and abdomen in three-year-old male. Sulfathiazole pressure dressings from the start. Grafted at second redressing 18th day, with surgical removal of burn slough. Twenty-eight-square inch cut from the midback region, 010 of an inch thick. Spotty 60 per cent take at third redressing, probably due to abdominal respiratory movement. Regrafted with complete take.

Comment An unfortunate graft take, probably due to abdominal movement.

Case 10—Flame burn, 20 per cent, from burning pyjamas in four-year-old male. Penis and scrotum burned superficially, both thighs and right lower leg deeply. Sulfathiazole emulsion routine from the start. Fourteenth day, as slough was separating, was placed in saline bath routine for 72 hours, with pain, rise in temperature and lowering of morale. Dressing routines resumed and grafted on 29th and 39th days with complete coverage and no resultant disability.

Comment A lesson on changing treatment routine. Grafting should have been started at the 14th day, redressing instead of the change to saline.

Case 11—No 2888-42 Scald of thigh, knee and leg in 61-year-old female. Thigh and knee treated with sulfathiazole emulsion pressure dressing, and healed in 18 days. A gentian eschar on the lower leg became infected and would not come off. Admitted to ward, eschar removed, pressure emulsion dressing for three days. Grafted, with 100 per cent take, and healing in 12 days.

Comment Should have been a ward case from the start. A lesson in comparative eschar and pressure dressing treatment.

Case 12—Bed clothing caught fire burning 41-year-old male from above the iliac crest to midpart of lower leg. Pressure dressing from start. Whole leg surgically debrided on 12th day, and upper part of thigh grafted with back skin cut at 008 inches, using three good sheets. Sixty per cent take at next redressing. Burn was deeper than suspected, and whole fascia lata from midthigh down was sloughing. Redressed and grafting completed about the 50th day.

Comment Our first delayed primary graft. It was difficult to assess the burn depth but there was a 60 per cent take of the skin grafted.

Case 13—No 2006-42 Ignited gasoline burn of chest and arms of 12-year-old male, 30 per cent deep burn Chest and arms allowed to granulate for three months under triple dye eschar Sulfathiazole emulsion and pressure dressing routine and grafting completed in two stages Heavy scarring where skin had grown in during the three month granulation interval

Comment The old method of delay and wishful hoping for skin coverage This child's illness could have been shortened at least two months

Case 14—Burn 25 per cent, of leg, both hands and face from ignited kerosene in 40-year-old male Deep burns of backs of hands grafted on the 34th day with outer thigh skin at 016 inch, with 100 per cent take

Comment Both backs and palms of hands and side of face subjected to same heat and only backs of hands show full-thickness burn

Case 15—No 6773-43 Hot paint burn of right shin region, 8 x 10 inches, in 30-year-old male, grafted with outer thigh skin, 010 inch thick, on the 21st day Surgical debridement before applying the graft About 90 per cent take

Comment The débridement was difficult and hard to delineate in the shin area

Case 16—Severe, deep 30 per cent flame burn in 23-month-old male child Immediate sulfathiazole pressure dressing routine when shock was controlled Complete denudation of abdomen and left leg down to ankle on the ventral surface Completely covered at third redressing using child's own back skin and two sheets of isodermal graft from the mother's buttock Case progressing

ASSESSING THE BURN DAMAGE

The significant features of the burn history and the clinical appearance of the burned areas are carefully assessed and provide the most reliable guides as to burn depth and the probability of skin grafting to come A scald from moderately hot liquid producing an erythematous or lightly blistered skin will undoubtedly be a superficial burn, healed at the first redressing A burn from excessively hot liquid or superheated steam with wide blisters and the intervening skin with a white, leathery appearance will be a deeper burn and need grafting Flame burns as from ignited clothing are uniformly deep, the skin is seared and one may plan on its surgical removal and early grafting Electrical burns are even more severe and often show very deep charring which may further complicate the skin grafting to follow

In assessing the burn damage, the extent is calculated and recorded following Berkow's tables We have discarded all previous classifications of depth, finding them confusing and of little practical value, and prefer to speak of superficial burns, which will regenerate quickly, and deep burns, which will require skin grafting

ISODERMAL GRAFTING

Grafting of other than the patients own skin has not been employed to any great extent but we believe that this procedure may be a great help in selected cases and that more experimental work is indicated. In Case 16 it permitted the covering, in a small baby, of a very large and dangerous burn area all in one operation, two sheets from the mother and two from the child being used. Sixty-four square inches were cut from the mother's buttock and about 60 square inches from the child's own back. This permitted complete surfacing of the child's burns in about an hour's time, which is a real achievement even if the mother's grafts are only temporary. The possibilities of fetal skin and fetal skin banks might well be looked into for just such cases. The two sheets of skin almost denuded the child's whole back while the two maternal sheets made little difference to the mother's buttock.

INFECTION AND GRAFTING

With the sulfathiazole occlusive dressing there has been no cross-infection and *Streptococcus pyogenes*, *Bacillus pyocyaneus* and *Bacillus proteus* have been notably absent. As these organisms are the great destroyers of skin grafts, their absence has been most welcome. *Staphylococcus pyogenes* and nonpathogenic skin organisms have been culturable from our wound surfaces but seem to be in an attenuated state, certainly not producing clinical infection, or if so, to a very limited degree. We consider them no contraindication to skin grafting.

GRANULATIONS AND GRAFTING

Skin grafting of the burned surface is preferable before granulations become manifest. Exuberant granulations are an abortive attempt at wound healing that has been unsatisfied by skin covering at the appropriate time. They are the result of prolonged wound treatment and are no serious contraindication to skin grafting, *provided they are removed*. We have preferred to remove them, scraping them down to a firm yellow base with a sharp scalpel, grafting at once, feeling this procedure preferable to applying surface medicaments or lotions in an effort to make them more acceptable. A skin graft does well on the granulation tissue base but may do poorly on the granulations. There is less bleeding if they are scraped rather than cut and the resulting base is more even. The skin graft is applied immediately and itself has a marked hemostatic effect on the numerous small bleeders.

THE CHOICE OF DONOR SITES

The Padgett dermatome makes most body surfaces available for skin. The skins of abdomen, chest front, bicipital region and inner thigh are thin, and our preference has been for the thicker, better texture skin of the

back or loin regions. Outer thigh skin is midway between in quality and this site is most handy and accessible. Our abdominal and lower front chest donor sites have healed poorly compared with the other sites. We feel this is due to the difficulty of restricting the respiratory movements in these areas and that the pressure dressing is here less effective. Our donor sites are dressed in identically the same way as the original burn and the dressing left for at least two weeks or longer, until it practically falls off. Early removal is liable to damage a reforming epidermis. The donor sites are not, if possible, redressed and brought out into the air with vaseline or olive oil massage.

TIME OF GRAFTING

We prefer, if possible, to graft at the first, second or third redressing, and rather the first than the third. This may entail, and usually does, surgical removal of the damaged burn tissue but this is no more than the old method of surgical débridement, only done at a better and controlled time, both as regards the patient's general and local condition. It is simply débridement on the tenth to 14th day and covering the wound with a dressing—the skin graft. This is a delayed primary graft, the usual type. An immediate primary graft may be done on selected, circumscribed, obviously deep burns in which there is no threat of shock or toxemia.

PREPARATION OF THE BURNED AREA

We wish to emphasize the fact that with the technic advocated no other preparation of the burned area for grafting is necessary than the removal of the dressing and subsequent débridement of the area intended for grafting.

DEEP BURNS NOT GRAFTED (6 CASES)

There were six cases of 10 per cent burns, or over, that had patchy areas of intermediate deep burn which were not considered extensive enough to necessitate grafting. None of them was severe enough to threaten life. These cases were all treated by multiple, infrequent pressure dressings with sulfathiazole emulsion, changed at from seven- to 14-day intervals. Their average healing time was 24 days, the longest being 40 and the shortest 18 days. *None showed evidence of invasive infection, and epidermization was rapid and progressive.* This is the point desired to be brought out in discussing this group but it is equally applicable to all the other groups.

BURNS WITH PREEXISTING INFECTION

In this series there was a group of 22 superficial burns showing clinical evidence of infection on admission, as a result of delay, neglect or unsatisfactory self-treatment. The time-lag between the burn and hospital care

varied from one to 17 days, the average being five. The preliminary treatment, self-inflicted, or otherwise, varied from nothing to tannic eschar, while sodium bicarbonate, boracic and saline compresses were common. Cod liver oil had been used in three cases. In all of the cases there were local signs of invasive infection and eight had definite lymphangitis and adenitis. All of the cases showed fever and this was quite high in several. Cultures from the burned areas yielded both pyogenic streptococci and staphylococci in most instances. In all but two instances a single compression dressing sufficed to produce control of the infection and healing. The two exceptions had two dressings each. One of them is illustrated in color in the original paper¹. The point to be brought out in this group-study is that saline baths and other types of local therapy are not essential for such cases. On the contrary, the sulfathiazole emulsion under the occlusive compression dressing was adequate. Oral sulfonamide therapy, advocated by some authors² as necessary for control of infection in burns, was not used in any of these cases. It may be argued that oral therapy should have been used in the presence of lymphangitis. With this viewpoint we will not take issue, and it may be advisable at times. We did not use oral therapy in order to avoid confusing the issue. The average period of time of the single dressing in these cases was nine days, the longest being 17 and the shortest five days. The average number of hospital days was 11, the longest being 21 and the shortest seven.

FRESH SUPERFICIAL BURNS (35 CASES)

(Contaminated but apparently not infected) —Thirty-five cases of superficial burns from all causes, involving over 10 per cent of various parts of the body have come under treatment within a few hours of the accident. The average time-lag between burn and treatment is over an hour. Several, however, were from four to six hours before admission. Just as in the case of wounds, these burns are presumed to be contaminated, though on admission there was no evident infection. The average area burned in these cases was 20 per cent, and six were between 25 and 30 per cent. Consequently, many were serious burn problems. The flash or explosive type of burn involving both upper extremities, face, head, neck and part of chest is typical of this group. This has been found to be a common industrial type of burn. Most of the cases were in moderate to severe shock and required antishock general treatment. Under such controlled measures nearly all responded so well that plasma could be discontinued after 24 hours. Several subsequently showed definite signs of toxemia but it is noteworthy that only one of this group died, an infant of six months who became comatose and anuric quite suddenly, in 30 hours, and died 36 hours after admission.

Our conception of these cases is that they must all be regarded as severe 'wounds,' with necessary antishock measures to be taken before dressing

them The amount of plasma administered on the average 20 per cent burn was rather less than we anticipated A single dressing sufficed for the local treatment of all of these cases It was removed in the average case on the eighth day, the shortest time being six days and the longest 15 The average number of days in hospital was ten, the shortest being six and the longest 18 Again it should be pointed out that oral sulfonamide therapy was not used in any of these cases

MISCELLANEOUS CASES

Fourteen miscellaneous cases are included as a group in this series They are grouped as such because, for one reason or another, they did not fall into the other five groups Among the reasons may be noted the following

(a) Eight of them were under 10 per cent of body surface but involved special areas, and were considered severe enough problems to be hospitalized This lot included four burns involving the face, ears and eyelids These averaged only 5 per cent but special complications were feared, though they did not materialize The four others involved one or both hands and forearms and were considered to be fairly deep burns All eight cases eventually healed without grafting and with, at most, two dressings The average time in hospital was ten days, the shortest being six days and the longest 18

(b) The other six cases were 10 per cent, or over, superficial burns who had involvement of special areas such as buttocks and anal region, scrotum, labia, and one of both feet (rare) They mostly presented the problem of special and more frequent dressings In such areas as scrotum, labia, anal region or perineum it is obviously difficult, if not impossible, to apply a satisfactory compression dressing In such areas the emulsion has been used as a cold cream on gauze dressings held in place by T-binders and changed when necessary to toilet properly While it is impossible to maintain the same degree of noncontamination in such cases, the burned areas were kept remarkably clear and healed well without grafting The average number of hospital days was 12, the longest being 21, the shortest ten None of this group received oral sulfonamide therapy

COMMENT Without exception, all of the 100 cases in this series have been treated according to the plan suggested in the original paper However accumulated experience has caused the adoption of certain minor modifications This evolutionary effect is only natural, as increasing experience has led to crystallization of thought The planned management may now be said to have matured further Additional improvement in any such system may be expected, and is naturally hoped for A study of the Operational Chart, in comparison with the original, will show in detail how this progress has been effected The principal changes may now be discussed briefly

The most significant change to be noted is the elimination of all reference to eschar therapy This has come about as a direct result of our knowledge that such therapy definitely obstructed the plan for early grafting of the deep burns, and that in more superficial ones the further destruction of skin, with

or without infection, caused such delay in healing as to make eschar therapy undesirable. All this quite apart from the argument regarding the toxicity of tanning agents, and other undesirable or questionable features. When compared with our experience in previous years with eschar therapy, the compression dressing has given so much better results that the former has now no recognized place in our burn management.

Regarding the "timing" of dressing change, we have found that, contrary to our early impressions, weekly or earlier redressing was undesirable. We now believe that the frequency of dressing depends upon the depth of the burn and whether grafting is to be anticipated, or not. Thus, in all obviously superficial burns, a single dressing for a week will suffice, and it would be superfluous to keep the dressings on longer. Therefore, in such cases, *i.e.*, flash burns, we follow the foregoing rule. In deeper burns, on the other hand, it is unnecessary to remove the original dressing until from 10-14 days, when débridement of the surface may be carried out and grafting commenced at once. Longer periods for the original dressing have been found unnecessary. Burns of the face, originally treated with a cotton mask, have now been found to be particularly adaptable to a compression dressing. Under this treatment there is less edema and healing is more prompt.

MANAGEMENT OF SHOCK IN BURNS

The early recognition of oncoming shock and its prompt treatment are of prime importance in the management of burns. It is generally admitted that hemoconcentration due to loss of blood plasma from the effective, or circulatory blood, is encountered in extensive burns.

A study of the cases in this series indicates that other factors may contribute towards its production. Shock in burns can, and does, exist in the absence of hemoconcentration, as determined by hemoglobin and hematocrit determinations. Let us take for example the case of No. 4402-43, a nine-year-old boy, with a 32 per cent burn from hot cinders. Six hours after receiving his burns he was obviously in shock, cyanosed, sweating, with unobtainable blood pressure and pulmonary edema, yet the hemoglobin was 92 per cent, the R. B. C. count 5,000,000, and the hematocrit value 45 per cent—perfectly normal values. Three hours later the hemoglobin was still within normal limits (80 per cent) although the hematocrit value had risen to 59 per cent, indicating severe hemoconcentration. In point of fact, shock in this case, we believe, was aggravated by a long surgical débridement carried out without anesthesia other than morphine, and was subsequently aggravated by hemoconcentration. In other cases loss of plasma proteins with replacement by crystalloids may precipitate shock in the absence of evidence of hemoconcentration.

It is manifestly impossible to predict on a clinical basis what factors, or combination of factors, are operating to produce shock in any given burned patient. The prevalent belief that a burn of a given area requires so many

liters of plasma to combat shock may be a good working hypothesis and of practical value where facilities for proper blood studies do not exist but it is not always sound therapy. When hemoconcentration does not exist, the too liberal use of plasma may result in edema of lungs, liver and kidneys, the only pathologic change noted in one of the fatal cases in this series. When possible, every extensive burned patient should be subjected to determinations of plasma proteins, hemoglobin and hematocrit estimations at two-hour intervals during the initial period and later if the shock seems imminent.

The type of therapy—whole blood, plasma or crystalloids—must be determined by the abnormalities which actually exist in each specific case. Likewise, the amounts to be employed should be judged solely on the basis of the degree of the losses in each instance, and by the promptness and completeness of the response. Overenthusiastic or improper type of therapy may be fraught with as much danger to the patient as if he were not treated at all. Fear, pain, chilling, loss of plasma proteins, as well as hemoconcentration, are factors of importance in the combating of shock in burns, and they must all be treated with due regard for the variables in individual cases.

Regarding the use of electrolytes for the patient in shock, we have, for over a year now, been strictly conservative in the use of 5–10 per cent glucose solution in order to prevent edema of both tissues and vital organs. Normal saline with its added risks of edema and sodium poisoning is prohibited except where biochemical examination shows a definite depletion.

SULFONAMIDE THERAPY

It is the belief of the authors that the most important feature of the local therapy is the surgical treatment and cleansing of the burns, followed by the application of the occlusive compression dressing. This brings the burn treatment into direct line with the surgical treatment of all other fresh trauma. Nevertheless, our experience has given us the profound impression that the addition of 5 per cent sulfathiazole in an oil-in-water emulsion gives an important additional factor of safety against invasive infections as well as providing a medium for adequate curtain drainage. The use of a wide 1–2-Mm curtain-mesh as a basic dressing is, we feel, a necessary and important adjunct to the bulky dressing. Two particular experiences have contributed to confirm our belief. *One is that we have not in a single instance in this series been embarrassed by the development of clinical evidence of invasive infection. The second, and more important experience, has been the control of preexisting infection simply by the standard treatment with sulfathiazole emulsion locally applied.* While our belief is expressed in this way we have used sulfadiazine orally or intravenously in three severely burned cases in whom pulmonary infection was suspected. Two of these cases are included in the deaths, and the third case proved to have a severe bronchitis which was controlled. We have not had

any frank pneumonias but feel that when such intercurrent respiratory infections threaten oral or intravenous sulfadiazine should be given. Apart from such cases the authors believe that, other considerations aside, the early use of these drugs in severe burns carries a grave, unnecessary additional risk to the liver and kidneys at a time when toxic manifestations from the burn itself are imminent.

To recapitulate, the oral dosage necessary to maintain a satisfactory tissue and serum level in the burned area is a menace to a severely burned person. Such is our feeling, and our experience, with the local use being so satisfactory we can see no object in putting an additional load on potentially damaged vital organs. Reference to our original paper will give the reader the results of local tissue concentrations upon which studies our conception of the rationale of local rather than oral or intravenous therapy is based.

ANEMIA AND HYPOPROTEINEMIA

The management of the severely burned patient must include therapy to combat protein and hemoglobin loss. In extensive burns this depletion is progressive and unless adequate replacement measures are instituted, may become a serious threat to life. At least it may do much to prejudice recovery and to prolong convalescence.

Hemoglobin loss should be corrected by the transfusion of whole blood, the best infusion fluid after the initial emergent period. The amount of whole blood used must necessarily be determined in each case by the erythrocyte count and hemoglobin estimation as determined from day to day. Iron in the form of Bland's mass 4 Gm daily per ora is well tolerated after the initial period of shock and toxemia.

Plasma proteins may be maintained either by the intravenous infusion of whole blood, plasma or other proteins suitable for intravenous use. Blood substitutes such as gelatin, isinglass, *et cetera*, may be of value as emergency measures, but they are inferior to whole blood in treating burn patients after the first 48 hours. Occasionally it may be necessary to maintain this intravenous therapy for a much longer period. This was amply demonstrated by Lund² in the Boston disaster report. As a rule however, the oral administration of protein is preferable to its intravenous use unless that protein be whole blood or plasma. High protein feeding is essentially the treatment in the later stages of severe burns when it is difficult to maintain normal levels. If the oral intake be insufficient, complementary intravenous amino-acid preparations should be employed. Frequent estimations of the plasma protein are obviously necessary.

The important role of early skin-grafting in the conservation of protein and hemoglobin is already discussed in this report.

BURN TOXEMIA

We are unable to offer any summary or comment on burn toxemia. We are convinced that toxic manifestations during manifest shock present a

grave risk in all severe burns. In our opinion, this unsolved problem deserves more serious consideration and research than it has hitherto been given. There are probably many toxins involved and until more data are available on their characters adequate measures for prevention and treatment are not possible. *Is this not the remaining major problem in a severely burned patient?*

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REFRIGERATION ANESTHESIA IN SURGERY*

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ALLEN,¹ in 1941, was the first to demonstrate clinically that a tourniquet could be applied to a limb and that the part distal to the tourniquet could be enveloped in ice to produce after a suitable period of time surgical anesthesia. Not only was anesthesia complete but subsequent operation could be achieved in a bloodless and practically shockless field. This method of refrigeration anesthesia, it soon became apparent, was particularly suitable for leg amputations in extremely poor-risk patients suffering from diabetes or arteriosclerosis. During the past two years numerous clinical applications of refrigeration anesthesia have been suggested, and considerable experimental work has been done in an effort to augment our understanding of this novel technic. All authors have implied, however, that many aspects and uses of this method are disputatious, and have encouraged further reports of clinical experiences with its proposed applications. We have recently had two unusual and interesting experiences with refrigeration of limbs. These cases were followed with interest by the members of our surgical staff, and they were managed with the view in mind of trying to clarify by clinical research a few of the polemical aspects of refrigeration anesthesia.

SUMMARY OF CASE REPORTS

Case 1—Clinic No 82438 L M, white, female, age 52, had a long history, with numerous hospital entries for chronic pyelonephritis, with a ureteral stricture, diabetes mellitus, and obesity. She was being observed on the Gynecologic Ward for her pyelonephritis at the time of present admission. At 5 A M July 17, 1942, she was seized with a sudden severe pain in her left leg. The leg rapidly became cold and motionless. We first saw her at 1 P M, approximately eight hours after the onset of pain. The entire left lower extremity was cold, hard, white, and motionless. Sensation was markedly diminished, but spontaneous pain was considerable. Femoral, popliteal, and both pedal pulses were absent. The right lower extremity was normal. She was not fibrillating, nor had she been at any time to our knowledge. Clinically, her heart and lungs seemed clear. Electrocardiograms in 1937 and 1941 were normal, but that made on July 20, 1942, showed abnormal T-waves with left axis deviation.

A diagnosis of femoral artery occlusion from an embolus was made. Papaverine, 50 mg intramuscularly, and lumbar sympathetic block with 2 per cent novocaine failed to relieve her pain or increase the warmth of the extremity. Femoral embolectomy was decided upon, and carried out 11 hours after the onset of her difficulty.

Under 1 per cent novocaine anesthesia through a longitudinal incision crossing Poupart's ligament, the common femoral artery and its deep and superficial branches were exposed. The common femoral was occluded by an embolus, 2 cm long by 1 cm

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wide Pulsation was present in the common femoral artery above the embolus but not in the superficial or deep femoral branches The embolus was removed from the common femoral artery, and large static thrombi sucked out from both the superficial and deep femoral arteries by an oiled catheter Mild back-bleeding was finally obtained from both the superficial and deep femoral arteries, but neither of these vessels pulsated after closure of the incision in the common femoral vessel The common femoral vein was not ligated

Postoperatively she was given heparin by continuous intravenous drip, and also dicoumarin by mouth She had an embolus to the right radial artery on the first postoperative day, but the hand remained warm By the third postoperative day the circulation obviously had not been restored to the left lower extremity, and a line of demarcation separating warm from cold, dying tissue could be felt just above the knee On the fifth post-operative day it was decided to cool the left lower extremity in an effort to reduce its metabolic requirements for viability We hoped we might be able to preserve the limb while collateral circulation was becoming established

From July 22 to August 5, 1942, a cradle covered with ice-bags surrounded the left lower extremity The thigh was maintained at an approximate skin temperature of 18° C and the leg at 8° C, the leg being colder because of its poorer circulation No tourniquet was applied to the thigh True gangrene of the limb did not occur, infection did not appear, but the limb was obviously not viable for all sensation and motor power was absent Her general condition improved, but we abandoned all hope for the limb On August 5 a guillotine amputation was performed just above the knee under refrigeration anesthesia obtained by applying a tourniquet around the upper thigh

Following amputation the stump was surrounded by ice-bags for several days On the 7th postoperative day primo-secondary closure of the amputation stump was effected by tying preplaced stainless steel retention sutures All ice-bags were removed from the stump by the 10th postoperative day, but the tissues of the stump had failed to solidly agglutinate by August 27, 15 days after secondary closure Her plasma protein studies were normal, and vitamin concentrates had been forced during her entire illness On August 27 at 4 A M she became acutely dyspneic, shocked, cyanotic with an irregular pulse approaching 200/min Her lungs filled with bubbling râles, and frothy sputum appeared Phlebotomy was done, oxygen and digilaid administered, but she expired shortly afterwards Postmortem examination was not obtained She died either from acute heart failure or a pulmonary embolus

Gross examination of the amputated limb showed it to be gangrenous, but infection of the tissues and necrotic changes were minimal considering it had been void of circulation for 19 days The popliteal vessel was occluded by an organizing thrombus As soon as the thrombus was removed it was apparent the blood had not coagulated in the peripheral structures, for a radiopaque mass could be easily injected into the popliteal vessel and made to flow down the leg (Fig 1) Even the minutest vessels of the foot were patent (Fig 2) This raised in our minds the possibility of having saved this limb by doing an embolectomy from the popliteal artery Refrigeration of the limb had prevented gross necrotic changes in the avascular tissues However, microscopically, studies of the muscle, nerve, blood vessels, and skin of the amputated limb were discouraging The muscle was completely degenerated with only sarcolemmal nuclei remaining There was no sign of fibroblastic or muscle cell proliferation about the vessels of the perimysium or anywhere else (Fig 3) The small vessels contained very few cells which were chiefly polymorphonuclear and appeared to be on the point of migrating through the vessel wall The nervous tissue showed mild degenerative changes with infiltration of moderate numbers of polymorphonuclear cells (Fig 4) The skin showed necrosis of the dermis and subcutaneous tissue with a few inflammatory cells and pigmented nuclei (Fig 5) Mainly the epidermal papillae and a little of the deeper layers of the epidermis was necrotic The microscopic diagnosis was gangrene



FIG 1—Case 1 Arteriogram of amputated leg

of the leg. It seemed to us irreversible changes were occurring in the tissues microscopically, and that only the gross necrotic changes had been prevented by cooling.

COMMENT—This isolated experience of refrigeration of a limb which was the seat of an unsuccessfully removed arterial embolus was not gratifying. Although cooling of the anoxic limb had retarded the metabolic needs of the tissues and prevented gross necrotic changes, we felt it had not prevented gangrene, had caused the available collateral blood vessels to contract, and had retarded both the stimulus for and rate of growth of new collateral channels.

Case 2—Clinic No 211107 E M R, white, male, age 70, was admitted to the hospital, September 16, 1942, without diabetes, but with a history of claudication in the left lower extremity for over five years. For the past seven months he had suffered in addition from an indolent ulcer on the heel of the left foot and severe pain in the calf and foot preventing sleep. General physical examination was negative except for moderate generalized arteriosclerosis. In the left lower extremity the femoral pulse was barely palpable, the popliteal, dorsalis pedis, and posterior tibial pulses were absent. The foot was cold, blanched on elevation, and ex-

hibited dependent rubor. There was a small indolent ulcer on the medial aspect of the heel, but no gangrene of the foot or toes. He complained bitterly of pain in the foot. The right lower extremity was warmer, had a good femoral pulse, but weak popliteal and absent pedal pulses.

The pain in his left foot was so severe he insisted upon an amputation. We advised him that we might be able to relieve his pain by sectioning the superficial peroneal and sural nerves. We were particularly anxious to do this procedure under refrigeration anesthesia, and demonstrate by surgical biopsies of the nerve, muscle, skin and subcutaneous tissues any possible microscopic alterations in refrigerated tissues. Furthermore, we wondered if refrigeration would have any permanent deleterious effects on the foot after it had been allowed slowly to return to room temperature. He consented to our proposal, with the stipulation that we would amputate his leg if he was not satisfied with the results.

On September 17, 1942, a narrow rubber tourniquet was applied below the knee firmly enough to shut off the blood flow. The site of tourniquet application was chilled with ice for 15 minutes before applying the tourniquet. The leg was packed in ice and maintained at 2° C to 8° C for two and one-half hours. During the first hour he had moderate pain in his leg which was relieved by morphine gr ¼. Thereafter, pain subsided and the limb became anesthetic. Operation was undertaken after two and one-half hours of refrigeration. A section of the superficial peroneal and sural nerves

was removed and, in addition, pieces of the anterior and posterior tibial muscle groups. The tourniquet was released, hemostasis obtained by fine silk ligatures, and the incisions closed.

During the ensuing four days the extremity was allowed to warm up slowly, keeping it packed in ice-bags. At first he had no pain in the leg, but after two days he began having excruciating pain of a bursting character in the entire left lower extremity below the site of tourniquet application. There was complete anesthesia over the superficial peroneal and sural nerve distributions. Gross sensation was otherwise present. He had a complete paralysis of all extensor and flexor muscle groups. His toes became blue and mottled on the 5th day, *i.e.* one day after all ice-bags had been removed.

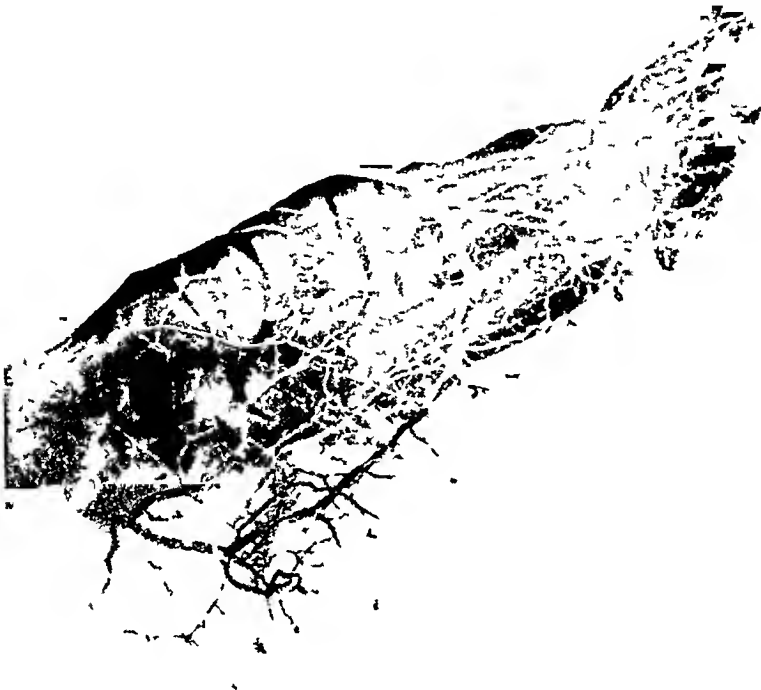


FIG 2—Case 1 Arteriogram of foot

Gangrene of his toes seemed imminent. There was no skin necrosis at the site of application of the tourniquet. The incisions seemed to be healing slowly, but because of the extreme pain and inability to move his foot he desired amputation without further procrastination. Midthigh amputation was performed under gas anesthesia September 22, 1942.

The amputated leg was examined carefully. The popliteal artery was calcified and its lumen occluded by an organized thrombus. It was impossible to inject it with radiopaque material to visualize the circulatory bed still patent. The muscular tissues above the site of tourniquet application looked normal, whereas the tissues below the site were gray, friable, and necrotic, particularly in the distal portions of the extremities. Careful sections were taken of skin, muscle, tendon, nerve and artery above and below the site of tourniquet application for detailed microscopic studies.

Figure 6 shows the normal appearing muscle after two and one-half hours of refrigeration. Figure 7 is the section of the biopsied superficial peroneal nerve, which also

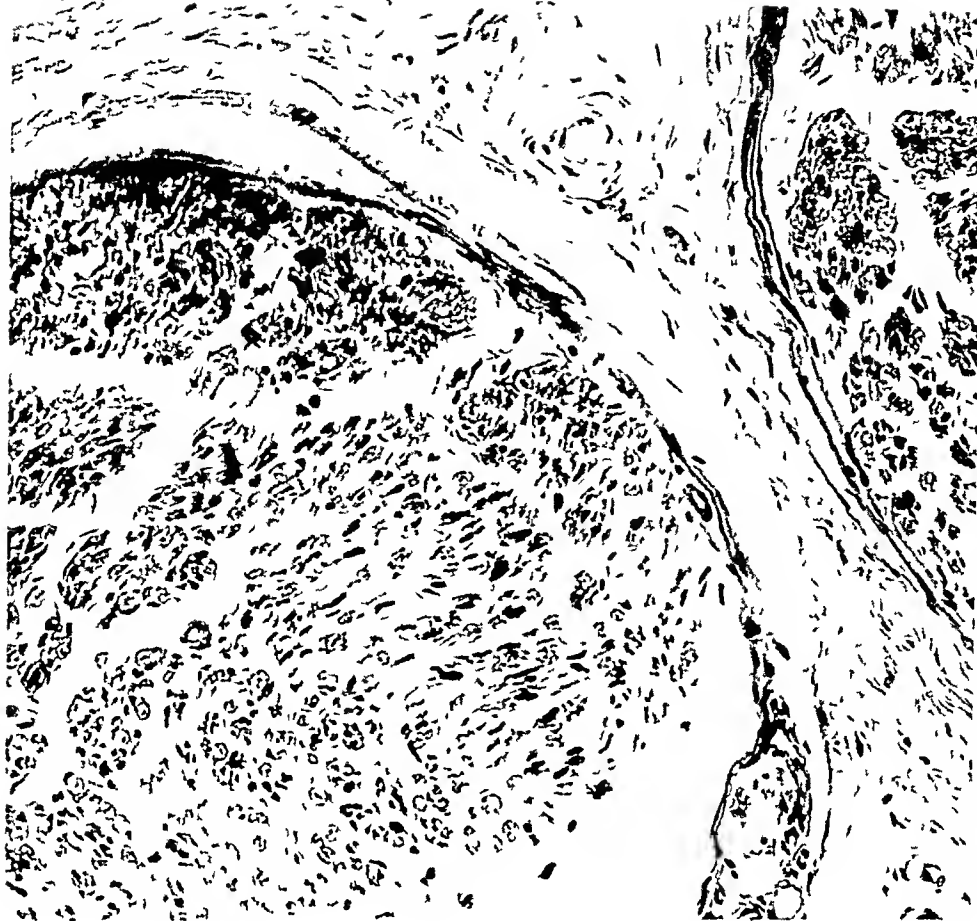


FIG 4—Case 1 Photomicrograph of nerve Mild degenerative changes, with moderate polymorphonuclear infiltration



FIG 3—Case 1 Photomicrograph of muscle Complete degeneration with only sarcolemmal nuclei remaining No signs of fibroblastic or muscle cell proliferation

looks normal. In Figure 8 the appearance of the muscle tissue from the amputated limb is seen. There is marked separation of the muscle fibers which have lost most of their striations. Among them are scattered moderate numbers of polymorphonuclear leukocytes and macrophages. The nerve, Figure 9, now shows a mild polymorphonuclear infiltration. Section of the skin (Fig 10) shows normal cornified epidermis with dermis unchanged except for a few perivascular lymphocytes and moderate subcutaneous edema.



FIG 5—Case 1. Photomicrograph of skin. Necrosis of dermis and subcutaneous tissue, with a few inflammatory cells.

COMMENT—To our knowledge this is the first reported case in which a limb was actually refrigerated, and then allowed to slowly return to room temperature. While it is true we were dealing with a limb which already had an abnormal circulation, we are inclined to doubt that refrigeration anesthesia may be used successfully in lengthy reconstruction operations upon normal

limbs This skepticism would apply equally to the débridement and preservation of traumatized extremities Once a tourniquet is applied to a limb, even though the tissues distal to the tourniquet be cooled, irreversible changes in the specialized nerve and muscular tissues are apt to occur, unless the well-established principles governing the use of a tourniquet are carefully observed

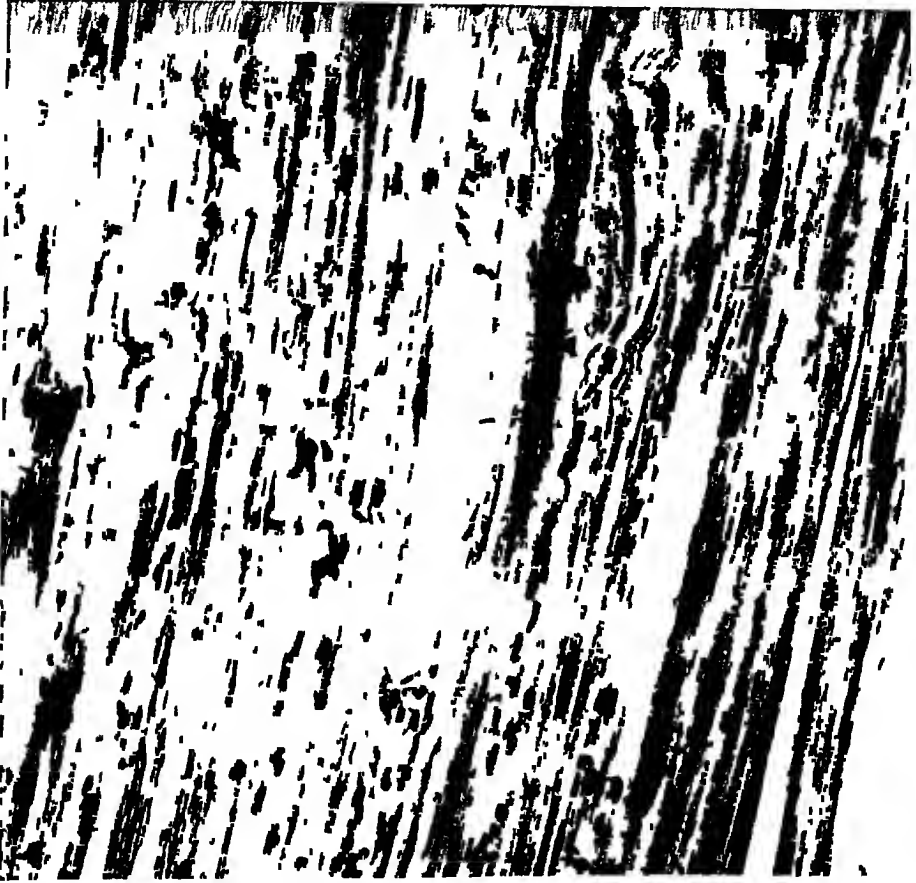


FIG 6—Case 2 Photomicrograph of normal muscle after 25 hours of refrigeration

DISCUSSION

In May, 1941, after several years of experimental work with the survival of tissues subjected to complete asphyxia induced by tourniquets, Allen¹ suggested, and demonstrated, the applicability of refrigeration anesthesia in clinical surgery Briefly, the initial method of refrigeration anesthesia consisted in applying a narrow band-like (2 cm) rubber tourniquet to the limb tight enough to obstruct all blood flow distal to it The limb, including the tourniquet site, was encased in thin rubber ice-bags, or cracked ice, and maintained at about 5° C until anesthesia was complete Ordinarily, this required about one to two and one-half hours for the lower leg and three and one-half to four hours for the thigh This method of anesthesia was designed to lower the mortality rate for leg amputations in extremely poor-risk patients, particularly in those suffering from diabetes or arteriosclerosis The anesthesia was "protoplasmic," in the words of Allen, that is, all living

tissues and protoplasm were anesthetized, not only the nervous tissue. The operation could be carried out without haste in a bloodless field. Anesthesia lasted an hour or more, if cool solutions were used for sponging during the operation. Once the tourniquet was removed sensation returned in 15 to 30 minutes but all bleeders could be tied and the skin closed, ordinarily with complete anesthesia. Operative shock was nonexistent because of the



FIG 7—Case 2 Photomicrograph of normal nerve after 25 hours of refrigeration

“protoplasmic” anesthesia. Postoperatively the stump was packed in ice-bags for several days to preserve the vitality of the flaps, inhibit shock, and prevent agglutination of the wound edges until clean healing could occur. The rate of healing was proportional to the postoperative temperature. Blood clotting and thrombosis of the vessels was prevented by cold, and emboli

from ascending thrombosis eliminated. Bacterial activity was likewise retarded by refrigeration.

Allen¹ emphasized that a tourniquet was essential to this method of anesthesia to permit chilling of the parts below it but prevent chilling of the remainder of the body. The tourniquet likewise prevents pain, shock and systemic infection from a badly traumatized, infected or asphyxiated limb. So long as the tourniquet remains in place, toxemia from the limb does not occur, but once a tourniquet has been elected for use in an asphyxiated or badly infected limb, it must not be removed until the leg is amputated, else overwhelming toxemia will ensue. Refrigeration inhibits the deleterious

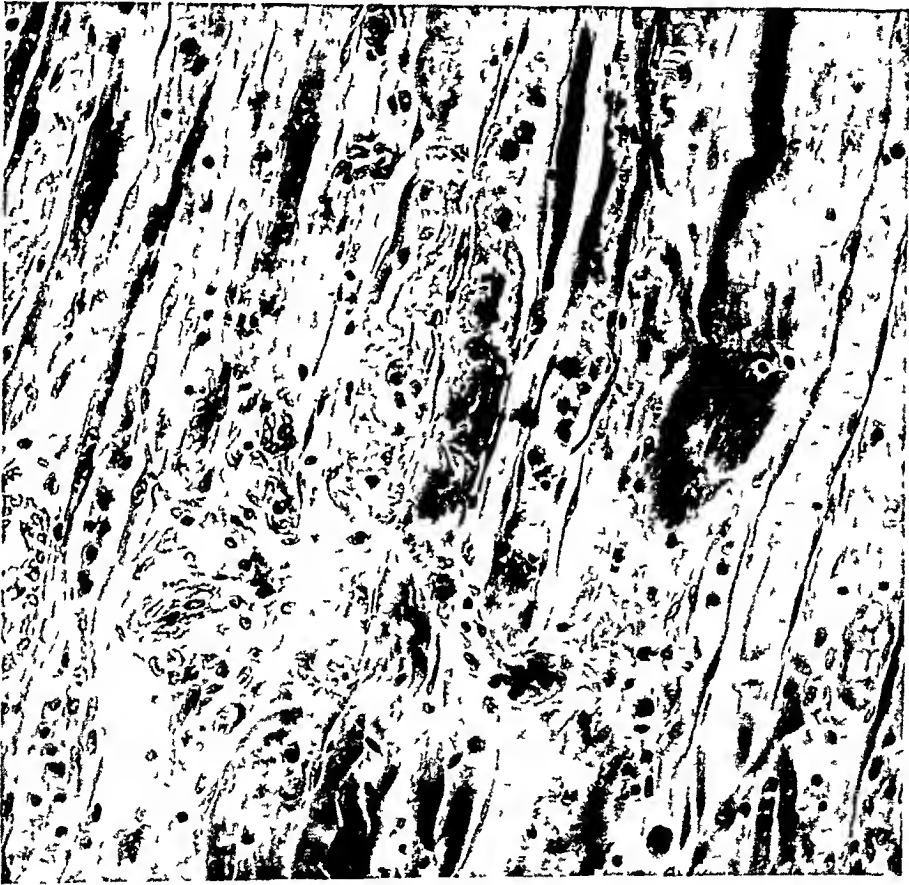


FIG. 8—Case 2. Photomicrograph of muscle from amputated limb five days later. Marked degenerative changes with polymorphonuclear infiltration.

effects of tissue asphyxia, infection and shock proportionate to the degree of reduction of temperature. Allen advised refrigeration of badly infected or traumatized limbs in poor-risk patients until the patient could be better prepared for surgery.

In this initial article Allen also suggested other possible applications of refrigeration anesthesia might be (1) Prevention of shock and infection in fractures, particularly those obtained in military life, (2) extension of the time limit for embolectomy with preservation of the limb by cooling until collateral circulation could develop—reduced temperatures would retard

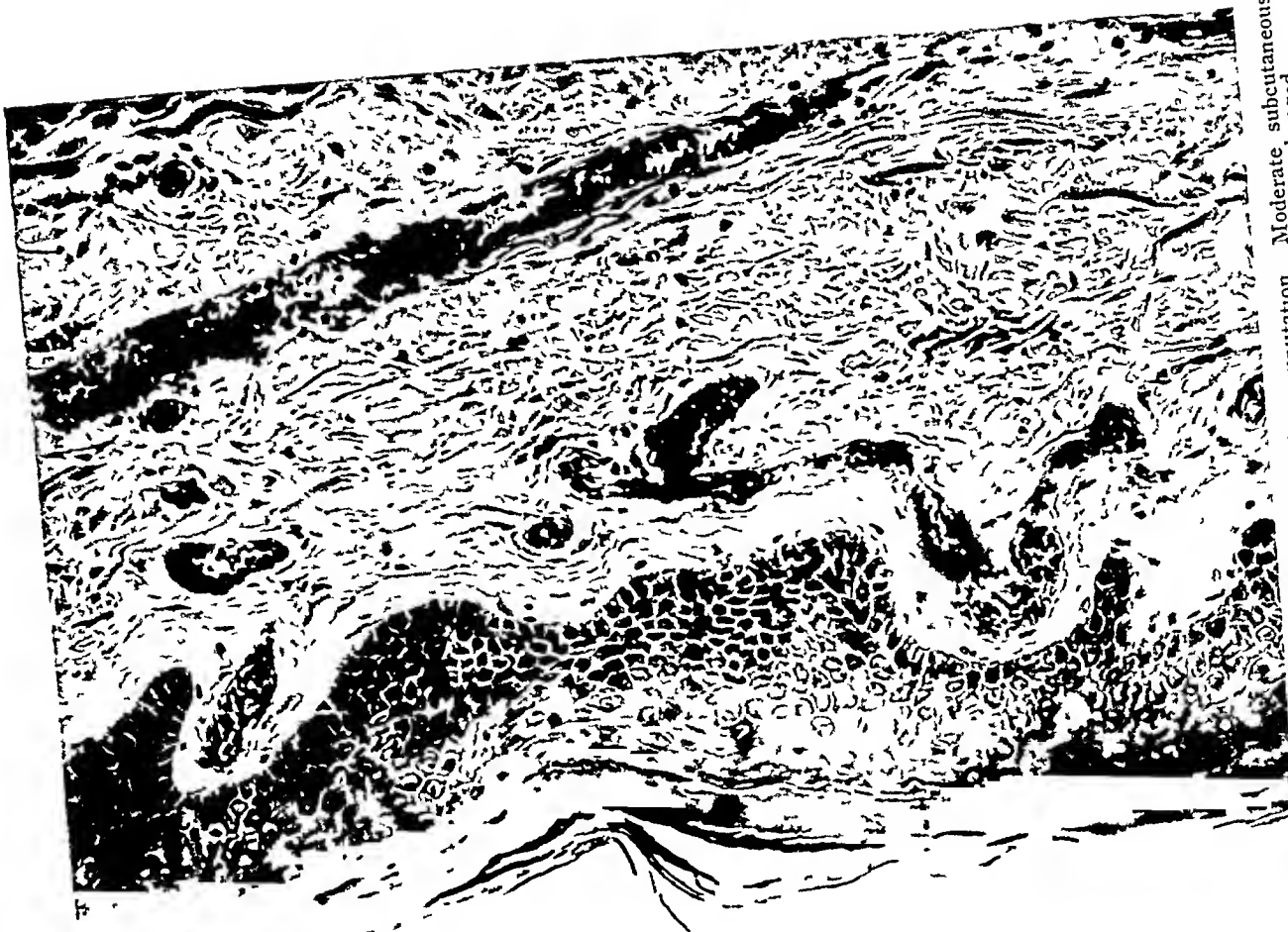


Fig 10—Case 2 Photomicrograph of skin after amputation Moderate subcutaneous edema and perivascular lymphocytes Epidermis and dermis unchanged



Fig 9—Case 2 Photomicrograph of nerve after amputation five days later Mild polymorphonuclear infiltration

thrombosis, necrosis and infection of the part, and (3) increasing the available tourniquet and shockless operative time in plastic and reconstructive procedures on limbs

Crossman, Ruggiero, Hurley and Allen² were the first to report a fairly large clinical series of cases subjected to amputation under refrigeration anesthesia. An analysis of 45 cases was presented. All of the patients were extremely poor risks for amputation, suffering either from diabetes, arteriosclerosis, or fulminating infection in gangrenous limbs. Fifty-seven amputations were performed, some of the patients being amputated below the knee initially to combat toxemia, and then later having a amputation of election above the knee. There were seven deaths in this series, a mortality rate of 15.5 per cent. Twenty-one leg amputations, and 36 thigh amputations were performed. Of the 21 leg amputations, some of which were done through areas of lymphangitis, there were three deaths, and only five failed to heal, successful healing occurred in 13. Of eight reamputations at a higher level in patients initially extremely toxic from sepsis, only one death occurred. They concluded that refrigeration anesthesia occasioned the patient no pain or loss of appetite, limited necrosis and stemmed infection in a gangrenous extremity, and militated against postoperative thrombosis and embolism. They recommended the tourniquet be of pure gum rubber and one centimeter wide, that refrigeration anesthesia could be maintained for several days, permitting initial low amputations through areas of infection in extremely septic patients, with subsequent reamputation at a site of election, and that primary skin closure could be countenanced frequently in the presence of ascending lymphangitis close to the site of amputation. Refrigeration did not reduce the local vitality of tissues, weaken the barriers to infection, or create additional dangers of thrombosis or embolism. These authors used complete refrigeration with a tourniquet in all of their cases. No pathologic studies on the refrigerated limbs were offered.

McElvenny,³ later the same year, reviewed the status of cooling of limbs in preparation for surgical procedures and presented some additional experiences of cooling limbs without a tourniquet. He mentioned the previously suggested use of refrigeration of a limb with an acute arterial embolus, lengthening the time available for embolectomy, but stated no case reports of such a nature could be found in the literature. Two of his cases were extremely interesting. One was that of a man who sustained a crush injury with traumatic amputation of both of his legs at the knees. He was in profound shock. The stumps were packed in ice without a tourniquet for 58 hours while he was treated for shock and pneumonia and prepared for surgery. At operation, under ethylene anesthesia, the stumps were cold and firm, the muscles red and healthy, blood clots were absent, and the dirt and sand did not adhere to the tissues. Primary healing of the stumps occurred. The man suffered pain in his stumps prior to cooling, but none thereafter. The other case was that of a 78-year-old man with wet gangrene of the lower leg. His leg was kept in ice without a tourniquet.

for 28 days, with no gross damage to the skin. He experienced no pain in the cooled limb. Later, a tourniquet was applied, and a mid thigh amputation performed. In neither of these cases were studies presented of the pathologic material obtained. But, McElvenny concluded that cooling without a tourniquet was bacteriostatic, prevented toxic absorption, and alleviated pain in a traumatized or infected limb. He again suggested the use of refrigeration in military surgery to combat shock and hemorrhage, and slacken infection until surgery is permissible.

More recent articles of clinical importance bearing particularly on the later refinements in the technique of refrigeration anesthesia, are offered by Crossman, Allen, Hurley, Ruggiero and Warden,⁴ and by Allen.⁵

It is interesting to examine the experimental observations which have induced Allen and others to express such bold convictions concerning the merits of refrigeration in surgery.

SURVIVAL OF TISSUES

Wilson and Roone,⁶ in 1936 studied the effects of constriction and release of a tourniquet upon an extremity. They applied a tourniquet to the hind legs of 19 dogs under barbitol anesthesia. Seventeen per cent of the control group died, all dogs whose extremity was ligated over six hours died, but all dogs ligated under three hours survived. The dangers from ligation of an extremity were (1) nerve palsies and contractures, due either to direct pressure of the tourniquet or asphyxia of the ligated tissues, and (2) shock on release of the tourniquet. They felt the shock was due either to absorption of toxic products from the ligated limb, or to local fluid and plasma loss into the ligated extremity. They favored the latter since death was always slow and late after release of the tourniquet, and since the average increase of weight in the ligated limb was 3.5 per cent of the total body weight. (Blalock showed that 2.4 per cent of the body weight lost as plasma over a 28.5-hour period was lethal to animals.) Giving large doses of blood and plasma increased the transudation of fluid into the damaged limb, but life of the animal was lost nevertheless. Amputation alone was ineffective in saving life once local swelling had occurred in the limb, but early amputation of the ligated limb combined with large doses of blood and plasma preserved life in these animals.

Allen,⁷⁻¹¹ in 1938 and 1939, published several articles dealing with experimental studies on the effects of tourniquets and temperature on various body tissues. He concluded that skin and nervous tissues were most susceptible to the effects of tourniquets, and that these effects were due either to direct pressure of the tourniquet or to local tissue asphyxia. The direct pressure of the tourniquet could be tolerated by skin easily for eight hours without local gangrene. He felt the paralyses occurring after prolonged application of a tourniquet were of two types: one, direct pressure of the tourniquet on the nerve, and two, asphyxia of the nerve. The nerve would recover in several hours from the effects of local asphyxia, but not from direct pressure.

To minimize the effects of direct tourniquet pressure, a narrow tourniquet not wider than two centimeters was advised. He also found that tissues subjected to complete asphyxia would survive for much longer periods of time than commonly thought. The leg of a rat would survive, for example for 13 hours, a dog for 15 hours, and isolated examples in the literature on human limbs suggest equal resistance of human tissues to prolonged asphyxia. The main complication from prolonged ligation of an extremity was secondary shock on release of the tourniquet. This shock varied in severity depending upon the duration of ligation and mass of tissue ligated. Mild to moderate degrees of shock could be controlled by replacement of local fluid and plasma loss, but severe shock necessitated early amputation in addition to fluid, plasma and blood replacement. He postulated a toxin was formed in asphyxiated tissues which augmented the severity of shock and required early amputation of anoxic tissue prior to absorption of the toxin into the blood stream, if life were to be maintained. The toxin was liberated and absorbed slowly, for it could never be demonstrated in the blood stream, nor was the blood of a shocked animal deleterious to other animals. In addition to the general effects of tissue ligation, he discovered various tissues had different degrees of resistance and reaction to asphyxia. Nervous tissue, for instance, was most susceptible to the effects of ligation, and, even there, motor fibers were more sensitive than sensory fibers, and peripheral nerves were more resistant than the brain and spinal cord. Muscular and fibrous tissues withstand the effects of asphyxia relatively well.

*Allen early noted that even slight elevation of the body temperature multiplied enormously the effects of mass ligation of tissues. Gangrene of the extremity occurred much earlier, and secondary shock on release of the tourniquet was proportionately greater. Using first the hind legs and abdomen of rats he found reducing the temperature of ligated tissue decreased the danger of both gangrene of the part and secondary shock. Later, working with rabbits and cats under light anytal narcosis, he demonstrated that by immersing the ligated limb in ice water a tourniquet could be left on the thigh for 24 to 30 hours and still have the animals survive on release of the tourniquet and allowing the limb to warm slowly. The animals had a sensory palsy for four to five days, and a motor palsy for eight to ten days, but thereafter nerve function seemed normal. He concluded that a slight elevation of body temperature, within the limits of fever, favored the appearance of local gangrene and shock, reducing the temperature correspondingly decreased the incidence of gangrene and shock. The best temperature for an asphyxiated limb was found to be approximately 2°C . On the basis of these experimental observations he postulated that refrigeration anesthesia could be used with benefit in the surgery of, (1) amputations, (2) emergency surgery, to control hemorrhage, shock and pain and permit later successful débridement or closure of wounds, (3) plastic surgery, enabling operations under tourniquets for three to five hours, or preserving skin grafts, and (4) arterial embolism or other vascular injuries, prolonging the feasible period for embolectomy.

or arterial suture by avoiding intravascular clotting, and the absorption of toxins from the asphyxiated tissues

Brooks and Duncan^{12, 13, 14} conducted some ingenious experiments on the effects of temperature on the survival of anemic tissues. They determined the minimum time for gangrene to develop in a rat's tail subjected to a constant pressure of 130 mm Hg at temperatures ranging from -5°C to 40°C . Between 1°C and 5°C the tail would survive over 96 hours, at room temperature it would survive 18 hours of pressure, but at 40°C it survived only three to four hours. Pathologic studies on the refrigerated tails revealed, however, that even though gross survival was apparent, microscopically, there was marked fibrous tissue replacement of the muscular and nervous tissues. Another interesting observation follows. The tails of two rats were subjected to a pressure of 130 mm Hg at 30°C for 16 hours, a time-period which would invariably produce gangrene. One animal was then subjected to a temperature of 40°C , gangrene began in two hours and was marked at 12 hours. In the other, the tail was maintained at a temperature of 1°C , the tail looked normal at the end of 24 hours, but 24 hours after the tail was allowed to return to room temperature gangrene was present. These authors offered the interesting suggestion that clinical gangrene was really a postmortem change which was readily influenced by temperature, but they wondered if tissue necrosis, of which the onset and extent cannot be clinically determined, was equally subject to temperature. They warned against the too rapid clinical use of refrigeration anesthesia. Temperature definitely affects tissue already necrotic or clinically gangrenous, but it might not alter the viability of tissue of poor viability but not dead. Cold lowers the circulation to a part as well as its metabolic needs, and many hours of refrigeration might hasten fibrosis of specialized tissues, such as nerve and muscle. They felt clinical experience was essential to answer these problems.

A recent clinical résumé by Freeman¹⁵ on the influence of temperature on the development of gangrene in peripheral vascular disease concludes that the optimum temperature for an extremity which is the seat of occlusive vascular disease is between 30°C and 34°C . Cold produces vasospasm, heat increases the metabolic demands of the tissues beyond their circulatory capacity, and may precipitate gangrene. Refrigeration is advised only for amputation.

CONTROL OF INFECTION BY TEMPERATURE

It occurred to Allen¹⁶ that refrigeration anesthesia might be helpful in combating infections in the extremities. Lowering the temperature would arrest bacterial activity and application of a tourniquet would prevent the flow of toxins or bacteria from the infected limb. The inherent danger, however, would be that on release of the tourniquet an overwhelming accumulation of bacterial and tissue toxins might be released into the circulation. In one group of experiments rat feces was injected into the legs of cats and dogs. Refrigeration for two to five hours with a tourniquet had no effect on the infections. Refrigeration for 24 to 48 hours with a tourniquet

resulted in improvement while the tourniquet was in place, but on release of the tourniquet extensive masses of tissue turned dark and gangrenous and the animals died despite early and high amputations. In the second group of experiments cultures of pure streptococci were injected into the legs of rabbits. These resulted in either a trivial local process or an overwhelming sepsis, but no true cellulitis or lymphangitis comparable to human infections. Refrigeration with a tourniquet held the infection in abeyance until the release of the tourniquet, but ultimately proved of no value. Clinically, therefore, it was suggested that refrigeration of infected limbs be used to stem the infection until amputation was performed, an infected limb should not be refrigerated with a tourniquet unless amputation is contemplated. More recent clinical experiences with cooling of infected tissues will be discussed later.

Brooks and Duncan¹⁴ studied the influence of temperature on wounds by injecting intracutaneously in the backs of anesthetized dogs oil of turpentine and *Staphylococcus aureus* cultures.

If the temperature of the wound was maintained at 40° C there was with both the oil of turpentine and *Staphylococcus aureus* injections marked inflammatory reaction in 24 hours and central necrosis of the lesion in 48 hours. If the temperature was maintained at 10° C only slight inflammatory reaction was present in 24 hours, and even at 48 hours gross inflammation was absent. Controls maintained at 37° C showed slightly less reaction than the group with increased temperatures. However, after 48 hours the cooled part was allowed to return to normal temperature, and it was observed that by 96 hours the lesions resembled a control group of 24 hours. Thereafter, the lesions which had initially been cooled had slightly larger necrotic centers than the control group, suggesting cooling, in fact, irritated the tissues, resulting in a more marked inflammatory process eventually. These authors expressed the opinion that cooling inhibited bacterial growth and toxin production. The inflammatory process in the deeper tissues was not affected, for these structures were perfused by constant temperature blood. They concluded by warning against the indiscriminate use of either heat or cold on a traumatized extremity. No experiments were made on the fully developed inflammatory process.

Whereas the experimental evidence is not encouraging that cooling of an infected part has a beneficial influence on the structure, clinically refrigeration of an infected part with a tourniquet prior to amputation has proven an invaluable adjunct in controlling the toxicity and severity of a hopelessly infected limb. The clinical observations of Allen,¹ Crossman, Ruggiero, Hurley, and Allen,² McElvenny,^{3, 17} and Haley¹⁸ offer adequate testimony that tourniquet refrigeration of an infected limb prevents the subsequent absorption of toxic or degenerative tissue products, alleviates pain, and stems the virulence of the infection. All severely infected cases which have been refrigerated, however, have been amputated, and there are no reports in the literature of the use of cold to control infection, yet at the same time

preserve the limb McElvenny¹⁷ has reported two cases in which cooling without a tourniquet has been practiced (1) A 50-year-old man with traumatic amputations of both legs at the knees. The stumps were cooled by ice for 58 hours before attention to the local injuries was feasible. He felt the cooling prevented infection and preserved the vitality of the damaged stump tissues, and (2) a 78-year-old man with wet gangrene of the lower leg. The leg was kept in ice for 28 days without a tourniquet. The skin was not damaged, pain was relieved, absorption of toxins prevented, and a mid thigh amputation was performed later by applying a tourniquet.

To sum the evidence up, the infection in, and toxicity from, a hopelessly infected limb can be controlled by refrigeration with a tourniquet. Amputation can then be undertaken when the patient's condition permits. Cooling, *per se*, does not seem to have a beneficial effect on an inflammatory process. While the infected part is cooled there is an inhibition not only of bacterial growth and toxin production, but also of the normal tissue response. Release from the cooling may aggravate the eventual inflammatory response.

CONTROL OF SHOCK BY TEMPERATURE

While investigating tissue metabolism and the effects of local tourniquet asphyxia, Allen¹⁸ made some interesting observations on the secondary shock of the animals incident to the release of the tourniquet. He found applying a tourniquet to a limb was a simple, accurate, and controlled method of producing and studying shock. When the tissues of a limb had been subjected to an inadequate flow of blood for too long a period of time, death invariably resulted. This shock, which was accompanied by hemoconcentration, was felt by Allen to be due to local salt, water and plasma loss, combined with the production of a histotoxin in the asphyxiated tissues. Administration of blood, saline and plasma prevented hemoconcentration. However, after asphyxia of extensive masses of tissue, even though hemoconcentration was prevented by administration of blood, saline and plasma, death still occurred, presumably from histotoxicosis. Allen found that the effects of local asphyxia were aggravated by heat and diminished by cold. Specifically, in unanesthetized rats asphyxia of the hind leg could be tolerated at room temperature for only five hours without death of the animal, at 46° C, less than one hour, and at 2° C for eight hours or more.

Blalock and Mason,²⁰ in 1941, undertook a study of the comparison of the effects of heat and cold in the prevention and treatment of shock due to either hemorrhage or trauma. Dogs under morphine anesthesia were used to study the effects of hemorrhage, morphine and ether anesthesia was used to study the effects of trauma. Hemorrhage was simulated by removing three per cent of the body weight, or approximately one-third of the blood volume, from the femoral artery over a 30-minute period. Of the 14 control animals, 5 recovered, the average duration of life of the remaining 9 being 3 hours and 33 minutes. In 9 animals heat sufficient to elevate the rectal temperature 3.7° C was applied. All of these animals died,

the average duration of life being 5.5 hours. In 8 animals cold sufficient to depress the rectal temperature 12.3°C was produced. All of these animals died, the average duration of life being 11.5 hours. The application of heat or cold of these degrees did not alter the chances for survival, but the application of cold doubled the survival time of the shocked animal. Comparable results were obtained when the reduction of blood pressure to shock level (75 mm Hg) was studied by removing blood from the femoral artery. In the traumatic shock group 8 animals were subjected to elevation of body temperature of an average of 3.6°C , 15 animals were cooled an average of 6.6°C , as measured by rectal temperatures. The local fluid loss was about the same in the two groups. The only striking difference between the two groups were that the animals exposed to cold lived twice as long (6 hours and 35 minutes) as those exposed to heat and one of the cold animals survived. They concluded, "Significant elevations of temperature decrease the chance of life and shorten the period of survival. The application of cold does not increase the chance of survival but is accompanied with a lengthening of the survival of an animal with a low blood pressure. Significant elevations of temperature cause more disastrous effects than do depressions of similar degree."

Gratified with a satisfactory method of producing shock by crushing the hind legs of dogs in an irregular mechanical press, Duncan and Blalock²¹ experimented further with the effects of plasma administration and local cold application to crushed extremities. Of the control group at room temperature that had the hind leg crushed in the mechanical press for 5 hours, 20 out of 21 died. The average survival time was 8 hours, the average increase in the weight of the crushed limb was 3.3 per cent of the body weight. Fifteen dogs had their hind leg similarly crushed for the same length of time but were given plasma in amounts equivalent to 3.3 per cent of their body weight. Nine dogs died, the average time of survival being 20 hours. The average increase in the weight of the limb was 5.33 per cent of the body weight. Therefore, two-thirds of the plasma administered was lost at the site of injury. The 6 surviving animals showed severe shock with decreased urinary output, elevation of blood nonprotein nitrogen, and plasma creatine and creatinine. The legs became swollen with yellow fluid in the fascial planes. Suppuration occasionally occurred, as did nerve palsies. Microscopically, the tissues showed extensive scarring and replacement of the muscle with fibrous tissue. In 7 animals the effects of local cooling simultaneous with the crushing were analyzed. Only 2 of these animals died, both having pneumonia. The secondary shock and local fluid loss in the injured extremity was much less, however. Six dogs had the limb crushed for 5 hours, a tourniquet was applied, and 30 minutes later refrigeration of the limb was carried out. The tourniquet was removed after 1 hour, but the ice packs were maintained for 4 more hours. All of these animals died from severe shock, and the average fluid loss in the injured extremity was 3.7 per cent of the body weight. In 5 dogs the limb was crushed only for 3.5 hours, and then treated with the tourniquet and refrigeration as above. Three of these dogs died, with an

average fluid loss of 3 per cent of the body weight and marked hemoconcentration. Marked swelling of the limb, infection with scarring, and nerve palsies also occurred. Duncan and Blalock concluded that the deleterious effects of crush injuries or traumatic shock were attributable to toxin production, and local fluid and plasma loss in the injured part. Administration of fluid and plasma prolonged life by combating these elements in shock, but did not influence the production or effects of the tissue toxin. Freezing during the crushing period protected the animal considerably from shock and local fluid loss, for the metabolism of the tissues was reduced and less injury resulted from inadequate blood supply. Refrigeration after crushing had been completed had little or no influence on traumatic shock, for anoxia had already liberated its destructive weapons.

Later work, reported by Blalock and Duncan,^{22, 23} emphasized the extremely different effects between trauma alone and the same amount of trauma combined with the prolonged application of a tourniquet. Extremities were traumatized by striking the thighs of anesthetized animals a number of blows with a hammer. In one group no tourniquet was applied and plasma was administered in amounts equivalent to 5 per cent of the body weight. Every one of these animals survived. In the second group the same amount of trauma was produced but a tourniquet was applied to the limb for five hours. So long as the tourniquet was in place the animals remained unchanged, but on release of the tourniquet death ensued despite the administration of plasma in amounts equivalent to five to 10 per cent of the body weight. From the clinical standpoint, they cautioned strongly against the control of hemorrhage by a tourniquet, and advised, if a tourniquet is imperative, to cool the part distal to the tourniquet to reduce the chances of development of shock following the release of the constriction. However, the tourniquet must be left in place as short a time as possible, unless the part is to be amputated.

A good deal of the previous experimental work of Blalock, Blalock and Duncan, and Blalock and Mason, is summarized in a recent article by Blalock.²⁴ Using the same experimental method for studying the treatment of shock, the hind legs of large dogs, anesthetized with nembutal and morphine, were subjected to repeated blows with a blunt instrument for five to eight minutes. Ten animals were used for each method of therapy studied. If a tourniquet was applied it was left in place for five hours. The experimental results are shown in Table I.

TABLE I

SHOWING THE ILL EFFECTS OF A TOURNIQUET AND THE BENEFICIAL EFFECTS OF LOWERING THE TEMPERATURE OF A PART DISTAL TO A TOURNIQUET

Experimental Procedures	No	Tourniquet	Plasma (% Body Wt)	Animals Surviving	Time Survival	Regional Fluid Loss
Trauma, plasma therapy	10	0	5	8	8 days	
Trauma, tourniquet, plasma	10	5	5 to 10	0	14 hrs	7.8
Trauma, tourniquet, cold, plasma	10	5	5	5	17.5 hrs	5.42
Trauma, tourniquet, cold, no plasma	10	5	0	4	2 hrs 20 mins	5.41

Refrigeration was carried out by surrounding the limb in crushed ice, as soon as the traumatization was completed. These experiments substantiated previous work and confirmed the opinion that a tourniquet should not be applied to an injured extremity, for it burdens the patient with the harmful effects of anoxia plus trauma. If a tourniquet must be applied cooling of the part distal to a tourniquet lessens the ill effects of constricting and releasing the blood supply to an injured part. The beneficial effects of cooling of a part distal to a tourniquet may be due to a "slowing of the metabolic processes or to a number of other alterations."

TECHNIC OF REFRIGERATION ANESTHESIA

The two indispensable elements for obtaining satisfactory refrigeration anesthesia are (1) A tourniquet applied tight enough to completely obstruct all circulation to the distal parts, and (2) ice or another mechanism for maintaining the temperature of the ischemic limb between 2°C , and 8°C until anesthesia is complete. It must be realized that the tissues are refrigerated, not frozen. If they be cooled below 0°C , by adding salt to the ice or using other substances with a lower freezing point than water, the tissue will be frozen, and an irreversible change in the colloid structure of the tissues will occur. This freezing of the tissues or alteration of their colloidal state precludes the return to normalcy in the affected tissues. In our early experiences with refrigeration anesthesia salt was unwittingly added to the ice and sufficient care was not exerted in observing the temperature of all parts of the limb. When amputation of the leg was performed certain parts of the limb were refrigerated, but other parts were frozen. The refrigerated parts were soft, normal in appearance, but the frozen parts were hard, inelastic and solid. Fortunately, we escaped freezing of the tissues at the site for amputation in these cases.

The harmful effects of a tourniquet are due either to the local asphyxia of the structures deprived of blood or to direct pressure within the zone of the tourniquet. To minimize the local effect of a tourniquet Allen⁵ recommends a narrow (1.25 cm) band of elastic pure rubber tubing. On theoretic and experimental grounds this recommendation would apply for both the arm and leg, but clinical experience with tourniquets, in general, has induced us to favor the pneumatic blood pressure cuff for the arm. Nerve palsies occur less frequently with it than with narrow band tourniquets in the arm. In the leg, however, we have had no difficulties with the narrow elastic rubber tourniquets. This objection is immaterial if the limb is to be amputated, for skin necrosis at the site of tourniquet application is equally rare with either form of tourniquet. At any rate, for satisfactory anesthesia the tourniquet must be applied with sufficient pressure to completely obstruct all circulation to the limb.

After the site of tourniquet application has been chosen, ice-bags are applied around this site for 15 to 20 minutes to chill it. This renders subsequent application of the tourniquet almost painless. A tourniquet is then placed

around the chilled area completely occluding all blood flow distal to it (Fig 11) If no infection is present in the limb it may first be elevated and milked free of blood by winding the extremity with an Esmarch bandage The entire limb from the top of the tourniquet distalwards is enveloped directly in



FIG 11—Refrigeration Technic After chilling of tourniquet site with ice bags, the tourniquet is applied well above the site chosen for amputation

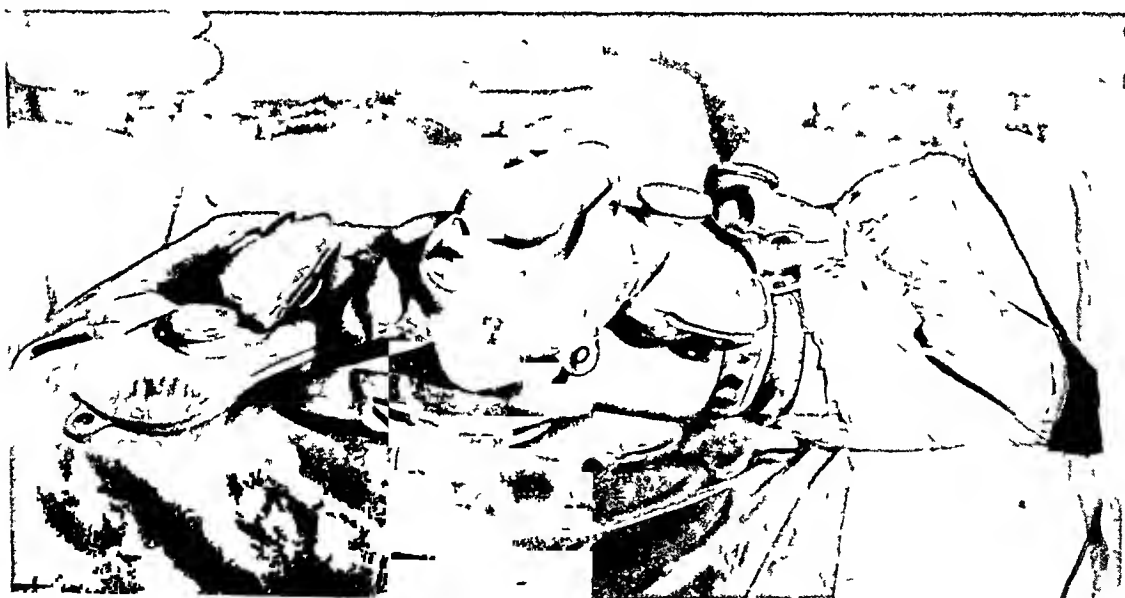


FIG 12—Refrigeration Technic Entire limb enveloped in ice bags, and outer casing of rubber sheeting wrapped around limb and ice bags

crushed ice or in thin ice-bags containing cracked ice Mild pain from the tourniquet may occur but this can readily be controlled by small doses of morphine Care must be taken to refrigerate all aspects of the limb The cracked ice or ice-bags are contained within a large rubber sheeting (Fig 12) To prevent flooding of the bed with ice water, the head of the bed is raised and the distal end of the rubber sheeting conducts the water into a pail If a thermometer is placed next to the skin the temperature ranges between 2°C

and 8° C. A low thigh or midthigh amputation requires 2 5 to 3 hours of refrigeration, the upper leg 2 to 2 5 hours, the lower leg 1 5 to 2 hours. The ice is not removed until the patient is in the operating room, and the tourniquet is removed on completion of the operative procedure. Complete anesthesia lasts from 1 to 1 5 hours, depending on how careful the operator is to avoid heating of the exposed tissues. Chilled saline has been recommended for moistening the tissues and instruments.

If the amputation is to be below the knee, and the patient can sit up in a chair, the leg may simply be inserted in a bucket of ice water to obtain refrigeration. The above-described technic, though simple and effective, is rather untidy, wet, and cumbersome, and several authors have recently reported mechanical devices to facilitate refrigeration without these inconveniences. Crossman, *et al*,² are using an electrical refrigerator thermostatically controlled at 40° F. to obtain refrigeration, and Haley¹⁸ has described a convenient metal cabinet to contain the limb and cracked ice during refrigeration. Haley also recommends the use of two tourniquets in infected and toxic cases, one applied during the initial upbuilding period at the tibial tuberosity, and the second applied at the upper thigh a few hours prior to amputation. This permits the area through which amputation is to be performed to be washed free of, and recover from, the effects of all absorbed toxins.

It is interesting to note that the tourniquet and refrigeration may be carried out well above the site chosen for amputation (3 to 6 inches) without fear of reducing the vitality of the tissues distally. No cases of slough at the tourniquet site or of the few inches of tissue distal to the tourniquet have been reported.

POSTOPERATIVE CARE

Postoperatively, the usual pressure dressing to and immobilization of the stump is carried out, and the stump is surrounded with ice-bags. In the ensuing 48 to 72 hours the number of ice-bags to the stump is gradually decreased, and by the 4th day no further cooling of the stump is necessary. Since agglutination of tissue fluids is retarded by cooling more serum than usual may drain from the stump, and healing is slightly slowed. Skin sutures, if used, should not be removed before the 10th to 12th day, but otherwise the stump heals satisfactorily. The degree and extent of postoperative healing can be somewhat controlled by regulating the cooling of the stump, and this is an advantage, particularly in infected cases, where too rapid healing is undesirable. Pain from an edema in the stumps is lessened by postoperative cooling.

Pneumonia is a definite complication from this method of anesthesia, particularly in the elderly, toxic, or poor-risk patients. Precautionary measures, as avoiding respiratory depression by excessive sedation, encouraging deep breathing exercises and coughing, frequent turning of the patient exercising of the arms and legs must be initiated immediately after operation.

If pneumonia or atelectasis does occur, full doses of one of the sulfonamide drugs should be administered

SUMMARY

From an analysis of the available clinical and experimental material many of the advocated advantages of refrigeration in infection, shock, traumatic injuries, vascular occlusions and reconstructive extremity surgery seem untenable. It was hoped that refrigeration might enable us to preserve the vitality of many limbs suffering from these afflictions which would ordinarily have to be sacrificed. Bacterial growth is retarded by refrigeration but so, also, is the tissue response to inflammation, and on release of the cooling the inflammatory reaction may even be aggravated.

In an injured extremity with an intact blood supply the application of a tourniquet is extremely hazardous, for it increases immeasurably the subsequent shock by adding to trauma the effects of tissue asphyxia. It is highly questionable if cooling alone of such a limb is of value. If a tourniquet must be applied to an injured extremity, then refrigeration of the anoxic parts distal to the tourniquet will lessen greatly the subsequent shock on release of the tourniquet. Care must still be exercised to avoid prolonged application of the tourniquet if the part is to be preserved, for although gross necrosis and postmortem changes in the asphyxiated tissues will not occur the highly specialized nerve and muscular tissues in the limb may be irreparably damaged by ischemic fibrosis. The same objection to refrigeration anesthesia may be voiced against its use in extensive reconstructive operations on an extremity where a prolonged bloodless and shockless field would be desirable. Similar objections obtain in using refrigeration in the presence of vascular occlusion of an extremity. If embolectomy fails to restore the integrity of the limb, cold would have a constrictive effect on the existing collateral circulation and would probably retard the development of new collateral channels. Without a tourniquet a limb could probably not be cooled sufficiently to prevent recurrent intravascular clotting in the damaged vessel following embolectomy.

It is true that refrigeration anesthesia has decided advantages in the control of shock, hemorrhage, and infection if sacrifice of the limb has been decided upon. Clinically, this has been particularly demonstrated in elderly, debilitated patients toxic from gangrene or infection in a limb. The application of a tourniquet combined with refrigeration will eliminate the absorption of toxins, promote bacteriostasis, avoid gross necrotic changes in the limb and permit removal of the limb in a bloodless, shockless and completely anesthetic field. Herein, lies the main advantage of refrigeration anesthesia. Lower amputations are permissible, necrosis of the stump is lessened, amputation may be undertaken through a potentially infected field, and subsequent drainage of infection in and healing of the stump controlled by postoperative cooling. The dangers of spreading thrombosis or embolism are obviated. Pneumonia postoperatively, must be cautiously avoided.

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REGENERATION OF PRE- AND POSTGANGLIONIC FIBERS FOLLOWING SYMPATHECTOMY OF THE UPPER EXTREMITY

AN EXPERIMENTAL STUDY

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CONSIDERABLE CONTROVERSY exists as to the explanation of the unsatisfactory results which occasionally follow attempts to relieve vasospasm by removal of the sympathetic innervation of the upper extremity. This study aims to provide an explanation for those cases in which the symptoms reappear after a postoperative period of several months. Excluding those individuals in which the return of symptoms might be explained by an increased sensitivity of smooth muscle to epinephrine following degeneration of postganglionic fibers the cases in which undesired results are obtained may be divided into two groups. (1) Those which show some persisting vasospasticity, and (2) those which are temporarily relieved but show a recurrence of sustained vasoconstriction after an elapse of several months.

The first group may show persistence of symptoms because of failure to remove the cervicothoracic ganglion and a sufficient number of additional thoracic sympathetic ganglia. Kuntz³ demonstrated that, to obtain complete sympathetic denervation of the upper extremity, in many cases the second thoracic sympathetic ganglion must be resected or isolated. This was shown to be necessary because postganglionic fibers originating from cells in the second thoracic or lower sympathetic ganglia are often present in the intrathoracic ramus which extends between the second and first thoracic nerves. Kirgis and Kuntz² reported the presence of a smaller and less frequently occurring intrathoracic ramus between the third and second thoracic nerves. Such rami constitute a pathway by which postganglionic fibers from as low as the third thoracic sympathetic ganglion might reach the roots of the brachial plexus independently of the sympathetic trunk. Moreover, the recurrent nerves that reenter the vertebral canal contain postganglionic fibers, some of which ascend and leave the canal along nerves composing the brachial plexus (Van Buskirk⁹). Thus, these fibers constitute another pathway by which vasoconstrictor impulses may reach the upper extremity following the common operative procedures.

Several theories have been advanced in an attempt to explain the recurrence of vasospastic symptoms following temporary relief. Sheehan⁴ suggested that preganglionic fibers may extend into the upper extremity to functionally replace the degenerated postganglionic fibers. However, he considered this improbable. Various workers have proposed that the return of vasomotor activity is the result of regeneration of axons whose cell bodies lie in sympathetic ganglia inferior to the usual level of trunk resection. It

has been suggested that these fibers rejoin spinal nerves to be distributed peripherally. Histologic evidence that such regeneration may occur has not yet been demonstrated.

White¹⁰ concluded that the recurrence of symptoms in Raynaud's disease, following sympathectomy of the upper extremity, is the result of an increased sensitivity of smooth muscle to epinephrine following degeneration of post-ganglionic fibers. However, at the time when the relapse usually occurs hypersensitivity to epinephrine is either absent or very much reduced (Simmons and Sheehan⁵). These investigators concluded that this return of symptoms probably is due to a regeneration of vasoconstrictor fibers. Smithwick⁶ states that the recurrence of symptoms following either pre- or post-ganglionic sympathectomy is undoubtedly due to partial regeneration of sympathetic fibers. He also suggested that recurrence of vasomotor activity may be the result of the regeneration of fibers from thoracic segments below the level of section of the sympathetic trunk.⁷ This worker, in an attempt to prevent such fibers reaching ganglionic cell stations, enclosed the second and third thoracic ganglia and the intervening trunk in a small, silk sack and ligated the cut end of the lower portion of the trunk.⁷

In experimental work on cats, Tower and Richter⁸ found no evidence, within 18 months, of functional regeneration of postganglionic fibers. However, they reported that preganglionic fibers regenerate within a month to make functional connections in the cervicothoracic ganglion. Evidence confirming these findings has been presented by Hinsey, Phillips and Hare.¹

MATERIAL AND METHODS

A total of 21 cats was used in this investigation. In each instance operative procedures were performed on the right side only, the left side remaining as a control. Animals were sacrificed at postoperative periods ranging from 28 to 300 days.

Based upon the experimental procedures utilized, the animals may be divided into three groups. Group A consisted of 12 cats from which the cervicothoracic and the second thoracic ganglia were removed. In addition, the third thoracic ganglion was removed in some animals of this group. Group B included three cats in which communicating rami were extirpated. In one animal the rami between the sympathetic trunk and the second thoracic nerve were removed, in the other two animals the rami between the sympathetic trunk and the eighth cervical and first thoracic nerves were removed. Group C consisted of six animals in which a cervicothoracic and second thoracic ganglionectomy was performed and the third thoracic ganglion isolated by section of the communicating rami. The cut end of the inferior portion of the trunk was ligated and drawn into a small tube, the upper end of which was then sealed with paraffin. The tube was sutured to the prevertebral muscles. A silver tube was used in three animals and a glass tube in the other three.

To obviate possible interpretation of sensory and vagal fibers as regenerated sympathetic axons, a supplementary operative procedure was performed on several animals 10 to 14 days prior to the termination of the experiment. This consisted of extirpation of the posterior root ganglion of each spinal nerve from the seventh cervical to the second thoracic segment inclusive. In addition, a segment of the vagus nerve was resected from the upper cervical region.

Upon sacrificing the animals a careful dissection was made of the sympathetic trunk, the vagus nerve and the thoracic and cervical spinal nerves. Connections formed postoperatively between the sympathetic trunk and the upper thoracic and lower cervical nerves were removed and prepared for histologic study. Some tissues were fixed in Bodian's No. 2 solution and stained by the protargol technique, others were prepared with osmic acid.

The extent of functional regeneration of postganglionic fibers was estimated by determining the activity of the sweat glands of the paw pads and the activity of the arrector pili muscles of the upper extremity. The function of the sweat glands was tested by the starch-iodine method, that of the arrector pili muscles by electrical stimulation of the thoracic sympathetic trunk inferior to the point of section. The extent of renewal of synaptic connections by preganglionic fibers in the cervical sympathetic ganglia was determined by the response of the pupil and nictitating membrane to electrical stimulation of the thoracic sympathetic trunk below the level of section.

OBSERVATIONS

Sympathetic denervation of the operated side was evidenced by a marked constriction of the pupil, projection of the nictitating membrane, elevation of the cutaneous temperature of the forelimb and inactivity of the sweat glands. Regeneration of preganglionic fibers was indicated by dilatation of the pupil and retraction of the nictitating membrane. This was observed in most animals by the end of the fourth postoperative month.

No indication of functional regeneration of postganglionic fibers into the upper extremity was detected by either the starch-iodine sweating test or by electrical stimulation of the sympathetic trunk inferior to the point of resection. However, the latter stimulation caused prompt and marked dilatation of the pupil in the majority of animals. Even those animals which were allowed the longest postoperative survival periods (300 days) showed, by the experimental methods used, no evidence of activity of postganglionic fibers.

Gross and microscopic examination of the sympathetic trunk and thoracic and cervical spinal nerves reveals that a rather extensive attempt at regeneration had occurred.

Removal of the posterior root ganglion of each nerve from cervical VII to thoracic II, inclusive, did not materially reduce the number of regenerating fibers. Resection of the vagus in the upper cervical region failed to modify the histologic picture.



FIG 1—Seventh and eighth cervical and upper three thoracic nerves and sympathetic trunk six months after removal of the cervicothoracic and second thoracic sympathetic ganglia (All photographs are unretouched)

FIG 2—Corresponding spinal nerves and sympathetic trunk of unoperated side from same animal as Figure 1

In those animals in which the cervicothoracic and the second (and in some cases, the third) thoracic ganglia were removed (Group A), dissections show considerable regeneration of fibers from segments below the second and third thoracic levels (Fig 1). The regenerating axons ascend from the cut end of the thoracic sympathetic trunk in several small bundles. Fibers which communicate with the nerves of the brachial plexus extend from these fasciculi. Many of the remaining components extend upward to the cervical sympathetic trunk, and other fibers are lost in the adjacent connective tissue. Regenerating preganglionic fibers emerge from the severed communicating ramus of the upper thoracic spinal nerves and become intermingled with those axons extending upward from the cut end of the thoracic sympathetic trunk. In all cases considerable scar tissue was formed in the region from which the sympathetic nervous tissue was removed. It was demonstrated both by dissection and microscopic examination that many fibers had established con-

nections between the cut thoracic trunk and the communicating rami, which had been severed at operation. This was noted especially in relation to the rami of the sixth, seventh and eighth cervical nerves. Both the experimental (Fig 1) and control (Fig 2) sides present a considerably larger communicating ramus to the seventh cervical nerve than to the other nerves of the brachial plexus.

FIG 3

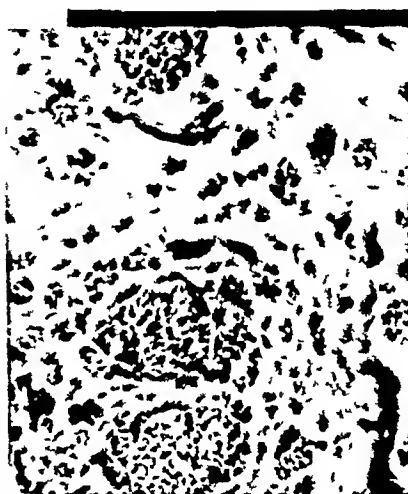
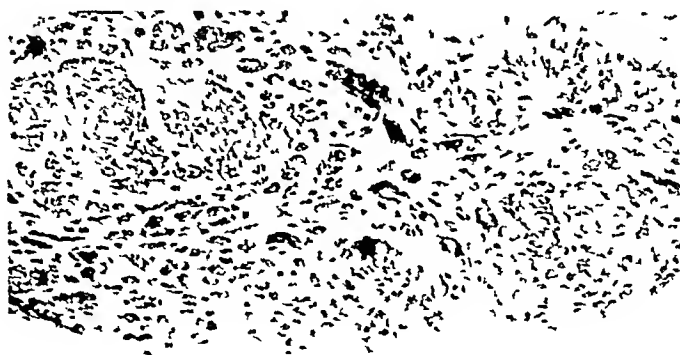


FIG 4



FIG 5

FIG 3—Transverse section of a portion of the regenerating sympathetic trunk immediately above point of section. (All photomicrographs show tissue prepared by protargol except Figure 5, in which the tissue was prepared with osmic acid.)

FIG 4—High power magnification of an area of Figure 3 showing thinly myelinated and unmyelinated fibers.

FIG 5—Area of a transverse section of the reformed communicating ramus between the sympathetic trunk and seventh cervical nerve.

Microscopic study of the bundles of nerve fibers issuing from the cut thoracic sympathetic trunk reveals many myelinated and unmyelinated axons (Figs 3, 4, 5). There is a marked predominance of thinly myelinated axons which undoubtedly are preganglionic fibers from lower thoracic segments. The number of regenerating unmyelinated fibers varies greatly. In some instances there are more of these fibers than in the control trunk, the excess in number of fibers is attributed to branching of regenerating axons. The communicating rami between the regenerating sympathetic trunk and the spinal

nerves are composed of both myelinated and unmyelinated fibers. These fibers are not segregated, both types occurring in all communicating rami. Histologic examination of the relation of these rami to the spinal nerves reveals that many of their unmyelinated fibers course with the nerves as small discrete bundles (Fig 6). The rami, in proximity to the spinal nerves, divide into fasciculi which join the nerves independently (Fig 7).

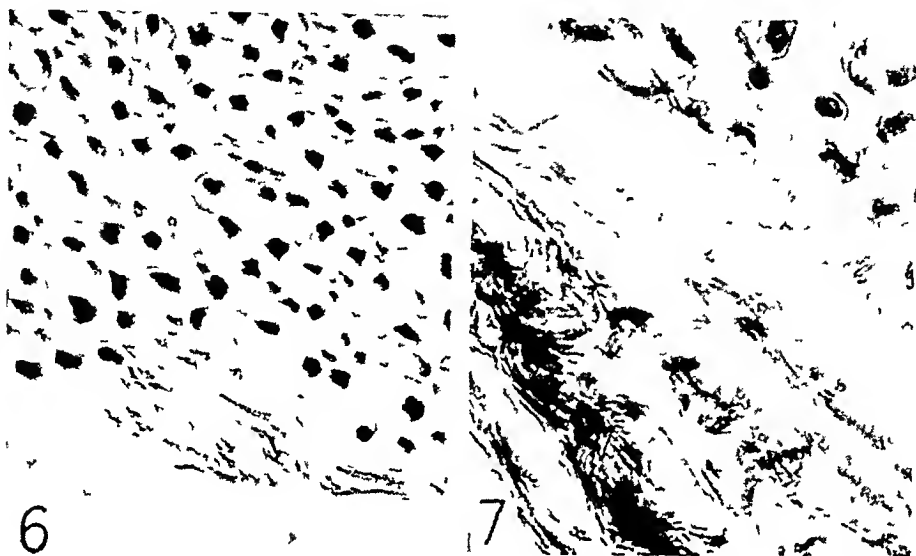


FIG 6—Transverse section of the seventh cervical nerve showing a small bundle of unmyelinated fibers coursing with the nerve

FIG 7—Transverse section of the seventh cervical nerve showing a small bundle of unmyelinated fibers joining the nerve

In Group B, in which communicating rami alone were extirpated, dissection shows renewal of connections between the sympathetic trunk and spinal nerves as early as four months postoperatively (Fig 8). Grossly, these communicating rami exhibit relationships to the spinal nerves similar to those between the rami and spinal nerves of the control side (Fig 9). Microscopically, these rami were found to consist of myelinated and unmyelinated fibers. These fibers are not as compactly arranged as in a normal ramus, instead they are grouped in numerous loosely placed fasciculi interspersed in connective tissue (Fig 10).

In those animals comprising Group C, in which the cervicothoracic and second thoracic ganglia were removed and a tube placed over the cut end of the inferior portion of the sympathetic trunk, renewed connections were found between the sympathetic trunk and the spinal nerves (Fig 11). The regenerating fibers emerge from the inferior end of the tube, which had not been sealed, and from that point the majority of the fibers turn and course superiorly. The number of the bundles of regenerating axons is considerably smaller than in those cats in which no steps were taken to prevent regeneration. The tube contains coiled myelinated and unmyelinated fibers and a small amount of scar tissue. In every case the tube is surrounded by a

REGENERATION AFTER SYMPATHECTOMY

connective tissue capsule which is penetrated by the regenerating nerve fibers. Figure 11 shows the course and character of these fibers as they reform the upper thoracic sympathetic trunk and communicating rami to the spinal nerves. As in Groups A and B, the regenerating bundles are formed of both myelinated and unmyelinated fibers.

Discussion—It has been demonstrated that the axons of the thoracic sympathetic trunk, following section of the trunk inferior to the second or third thoracic sympathetic ganglion, exhibit extensive powers of regeneration. This is more than a mere abortive, aimless growth of injured axons. Fol-

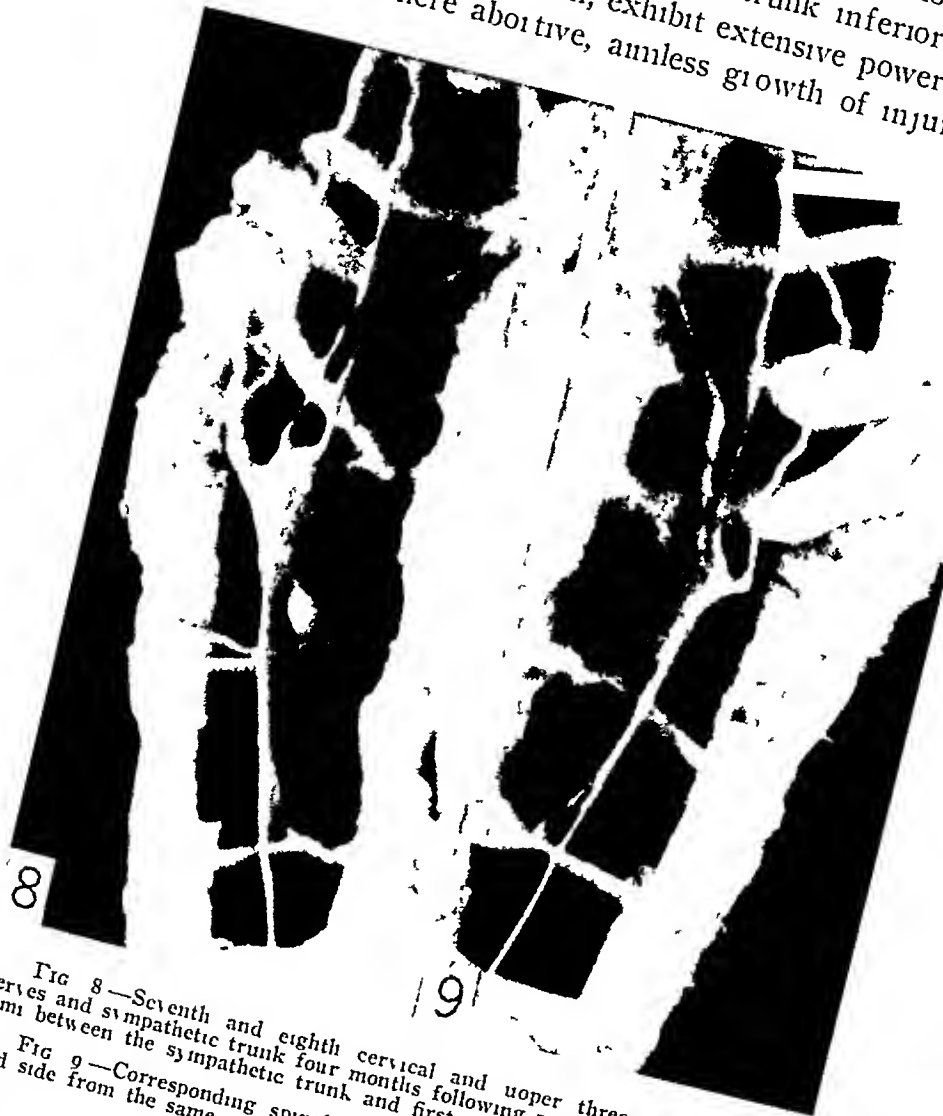


Fig 8—Seventh and eighth cervical and upper three thoracic spinal nerves and sympathetic trunk four months following section of communicating rami between the sympathetic trunk and first and second thoracic nerves

Fig 9—Corresponding spinal nerves and sympathetic trunk of unoperated side from the same animal as Figure 8

lowing removal of the cervicothoracic and the second and third thoracic ganglia, thinly myelinated fibers issuing from the upper end of the severed thoracic sympathetic trunk join similar fibers emerging from the sectioned communicating rami of the upper thoracic spinal nerves to reestablish continuity with the isolated cervical sympathetic trunk. Electrical stimulation of the thoracic trunk below the operative level resulted in prompt dilatation of the pupil in most animals which survived four months or longer post-

operatively. Therefore, these fibers must have regained synaptic relation with neurons of the cervical sympathetic ganglia.

These findings emphasize the necessity of taking special measures to obviate reestablishment of functional connections by preganglionic fibers with upper thoracic ganglia when the latter are not extirpated. Our work indicates that such connections would likely be made by a rather large number of fibers. Since the great majority of postganglionic fibers which pass to the upper extremity are axons of cells of the cervicothoracic, and the second and third thoracic ganglia, it would seem advisable to remove or isolate these ganglia. However, clinical reports (Smithwick⁷) have indicated that

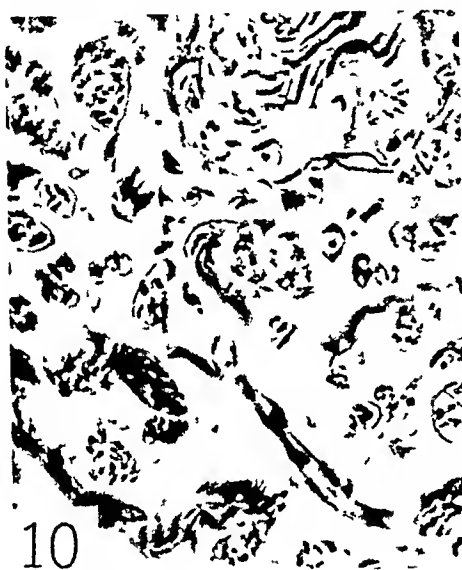


FIG 10—Area of a transverse section of a regenerated communicating ramus shown in Figure 8



FIG 11—Seventh and eighth cervical and upper three thoracic spinal nerves and sympathetic trunk following removal of the cervicothoracic and second thoracic ganglia and isolation of the third thoracic ganglion in a small glass tube

more favorable results are obtained if the postganglionic fibers are, insofar as is possible, allowed to remain intact. The procedure which has been recommended as giving most satisfactory results consists essentially of severing the sympathetic trunk immediately inferior to the third thoracic ganglion followed by extensive removal of preganglionic fibers of the second and third thoracic segments and isolation of the second and third thoracic sympathetic ganglia by enclosing them in a small silk sack.⁷ Our observations stress the necessity of preventing preganglionic fibers of lower thoracic segments from reestablishing synaptic connections in the isolated upper thoracic ganglia.

Unmyelinated axons accompany the preganglionic fibers which emerge from the cut end of the thoracic trunk. Numerous fibers of both types extend into the surrounding connective tissue and prevertebral muscles and

thus fail to reach a spinal nerve or sympathetic ganglion. Although many unmyelinated fibers join spinal nerves, experimentation reveals no functional activity of postganglionic neurons in the sympathectomized extremity. This is in accordance with the findings of Tower and Richter,⁸ who report no functional activity of postganglionic fibers in the upper extremity of cats within 18 months after sympathectomy. If functional connections are re-established by these fibers, as has been reported clinically, experimental evidence of their activity should have been obtained within 6 to 10 months. It would appear, from the extent of the regeneration which occurs centrally, that some of the fibers might reach the periphery. These experiments yield no such evidence.

Several of the explanations which have been advanced to account for the recurrence of vasoconstriction, following sympathetic denervation of the upper extremity, appear applicable in certain cases. The increased sensitivity of smooth muscle to epinephrine may be an important factor in the early return of symptoms when postganglionic fibers are destroyed. Relatively complete denervation might relieve symptoms temporarily but be followed by their reappearance due to more effective activity of the persisting axons. Postganglionic fibers may be capable of functional regeneration. Our work indicates that recurrent symptoms, following the common operative procedures, may be due largely to the regeneration of preganglionic fibers from lower thoracic levels and their regaining synaptic relation with cells in the isolated upper thoracic ganglia.

SUMMARY

1 Following extirpation of the cervicothoracic and the second and third thoracic ganglia, regenerating unmyelinated and myelinated axons ascend from the cut end of the thoracic sympathetic trunk. The majority of these myelinated axons are preganglionic fibers which join similar fibers from the upper thoracic segments and reestablish functional connections with cervical sympathetic ganglia.

2 Evidence of reestablishment of functional connections by the preganglionic fibers was found, in most cases, after a postoperative period of four months.

3 A considerable number of unmyelinated fibers from the cut thoracic trunk reenter upper thoracic and lower cervical spinal nerves via the cut ends of communicating rami.

4 Physiologic tests failed to reveal functional activity of postganglionic fibers within a postoperative period of 300 days.

5 Capping the cut end of the thoracic sympathetic trunk in a glass or silver tube was only partially effective in preventing regeneration of axons from the severed trunk.

The authors wish to express their appreciation for the kind cooperation and interest of Dr. Harold Cummins, Professor of Microscopic Anatomy, Tulane University School of Medicine, New Orleans, La.

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TOTAL PANCREATECTOMY FOR HYPERINSULINISM DUE TO AN ISLET-CELL ADENOMA

SURVIVAL AND CURE AT SIXTEEN MONTHS AFTER OPERATION

PRESENTATION OF METABOLIC STUDIES

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WE WISH TO REPORT A CASE in which complete pancreatectomy was performed for hyperinsulinism due to a small islet-cell adenoma located in the head of the pancreas near the duodenum. The case has several interesting features justifying its report. It is probably the second or third total pancreatectomy, and the first reported case known to us of complete pancreatectomy with survival following operation for more than a few weeks. It is the first total pancreatectomy for a benign lesion of the pancreas. The adenoma discovered in the removed pancreas is one of the smallest functioning islet-cell tumors reported, if not the smallest. Most important is the fact that the patient is living and well at the time that this paper is written, 16 months after the operation. Observations on the resulting diabetes and digestive disturbances are recorded.

CASE REPORT

The patient, a Jewish woman, age 49, registered at the Mayo Clinic July 6, 1942. She complained of fainting spells which had occurred intermittently during the previous three years. There were several different types of attacks, consisting of unconsciousness, dizziness, blank spells and sweating spells, all of which had been relieved by the administration of carbohydrate varying from orange juice to intravenously injected glucose. During one of the patient's unconscious spells, her physician had obtained a concentration of sugar that was less than 30 mg per 100 cc of blood. There had been five severe attacks of unconsciousness lasting from one to five hours. The minor attacks were more frequent than those of more severe character, and varied from dizzy or blank spells to attacks of sweating. These lasted from five minutes to one hour. During the blank spells the patient would feel rather foolish and be somewhat confused. Sweating spells would occur almost every day between 10 A.M. and 12 M. They were characterized by drenching perspiration, weakness and slight confusion followed by nausea.

* Since this article was written, Doctor Priestley has been commissioned Lieut Colonel in the Army of the United States.

They were relieved by orange juice or candy. The patient complained of feeling nervous and depressed, experiencing panicky sensations and feeling disoriented.

General physical examination showed the patient's weight to be 142 pounds (64.4 Kg). The systolic blood pressure was 140 Mm of mercury and the diastolic was 80. The results of examination of the heart, lungs and abdomen were essentially negative. Urinalysis, blood counts and serologic tests for syphilis gave negative or normal results. Roentgenograms of the head, thorax and lumbar portion of the spinal column were negative. The hepatic function, as shown by the bromsulfalein test, was normal. An electrocardiogram showed Rate 93, sinus tachycardia, slurred QRS complexes in derivations I and III, notched QRS complexes in derivation II, left axis deviation, notched P waves in derivations II and III, low amplitude T waves in derivation III. Leads IV-R and CR-2 showed positive T waves. The fasting concentration of sugar was 42 mg per 100 cc of blood, the concentration of calcium was 9.4 mg per 100 cc of serum. A routine 36-hour fast was started, but at 12 hours the concentration of sugar was 52 mg per 100 cc of blood, and at 18 hours the patient had a severe hypoglycemic crisis starting with drowsiness and sweating, and merging into stupor and unresponsiveness, and then into complete loss of consciousness, lasting between one and one and a half hours. Her concentration of sugar taken after the onset of this crisis was 29 mg per 100 cc of blood. Recovery was slow after intravenous administration of 20 Gm of glucose, followed by oral administration of 200 cc of orange juice. Anorexia with severe headache and fatigue followed the crisis but complete recovery was reached in 30 minutes. The concentration of sugar rose to 108 mg per 100 cc of blood after the glucose and orange juice had been administered.

A diagnosis of hypoglycemia, probably caused by hyperinsulinism, was made. It was our opinion that a tumor of the islets of Langerhans was present.

Operation—July 15, 1942. When the abdomen was opened, all of the visible structures, including the liver, appeared normal. There was no evidence of a malignant lesion. The pancreas was exposed by dividing the gastrocolic omentum along the greater curvature of the stomach and reflecting the stomach anteriorly and upward. Prolonged and careful palpation of the pancreas from the tail to the head did not reveal any evidence of tumor. The posterior aspect of the head of the pancreas was exposed by reflecting the duodenum medially but no lesion could be found in this portion of the pancreas. It was felt that there must be an adenoma present which was of the same consistency as the remainder of the pancreas and not situated on the surface of the gland, and that for this reason it could not be detected. At this time the situation was reviewed in consultation with Doctor Wilder, of the Metabolic Service, who was present at the operation, with the hope of determining the best procedure for the patient. It was known that she was incapacitated by her symptoms and it appeared quite certain that these symptoms were caused by hyperinsulinism. If only a portion of the pancreas were removed, it was known from experience that she would not be relieved unless an offending adenoma were present in the resected portion. Accordingly, it was decided to remove the entire pancreas.

The duct of Santorini was isolated approximately 1 cm proximal to the duodenum and was ligated. The duct of Wirsung entered the common duct about 0.5 cm proximal to the papilla of Vater, and this duct was ligated. The common duct was severed and ligated proximal to its entrance into the pancreas. The gastroduodenal artery, likewise, was severed and ligated. The head of the pancreas then was dissected free from the duodenum and mobilization of the gland toward the left was continued. Care was observed in order to avoid injury of the superior mesenteric vessels immediately posterior to the pancreas near the head of the gland, and the splenic vessels coursing along the superior border of the body and tail of the pancreas were preserved also. The pancreas then was removed in its entirety. The blood supply of the duodenum was then, of course, inadequate, and, accordingly, partial gastrectomy was performed, approximately

a third of the stomach and the first and second portions of the duodenum being removed and an anterior Polya-type of anastomosis being made. The duodenal stump at about the level of the superior mesenteric vessels was inverted. The gallbladder then was joined to the posterior wall of the stomach to establish adequate internal biliary drainage by cholecystogastrostomy. The patient was given a transfusion of 1,500 cc of blood during the operation.

Pathologic Report The pancreas weighed 80 Gm. Following prolonged search and many transverse incisions into the pancreas, a cellular adenoma of the islands of Langerhans, measuring $8 \times 5 \times 5$ Mm, was found situated in the head of the pancreas. The portions of the stomach and duodenum removed during the course of the operation were normal in appearance.

Postoperative Course—The postoperative course was uneventful. The patient's weight on admission was 142 pounds (64.4 Kg). On August 9, the first time after operation that she was weighed, her weight was 132 pounds (59.9 Kg). This gradually fell and reach 128.5 pounds (58.3 Kg) at the time of dismissal. The stools varied from two to six a day, usually about two to three after the patient began to take food. They were rather large, light colored and foul in odor at first, with some improvement by the time of dismissal. On August 4, the concentration of hemoglobin was 10.6 Gm per 100 cc of blood, erythrocytes 3,370,000 and leukocytes 5,600 in each cubic millimeter of blood. On August 19, the concentration of cholesterol was 216 mg per 100 cc of plasma, of cholesterol esters 121, of lecithin 301, of fatty acids 397, and of total lipoids 613. The concentration of calcium was 9.2 mg per 100 cc of serum. On August 1, after an Ewald test meal, the total acidity was 60 and the free hydrochloric acid 40, 150 cc was recovered in an hour and this contained a moderate amount of fine food remnants.

COMMENT—Reports of total pancreatectomy for benign or malignant disease of the pancreas are exceedingly rare in the literature. In 1908, Sauve¹ presented an extensive study on the subject of pancreatectomy involving the head of the gland. He collected data on 11 cases in which the operation was known to have been performed up to that time. He mentioned a case credited by Mayo-Robson at the Congres de Paris, in 1900, to Billroth in 1894, in which entire removal of the pancreas had been performed because of its involvement in a growth and the patient survived. Sauve was unable to find any published account of this case and he felt that there was insufficient evidence of the details to warrant its inclusion in his series. The only case listed in Sauve's series approaching total pancreatectomy was Franke's, in 1900. Here the surgeon attempted total removal because of the apparent involvement of the entire gland by a malignant lesion. He made the following statement: "Under the head of the pancreas, I found a little mass as large as a hazel nut, situated against the duodenum, I thought it was a question of a supernumerary pancreas, and I preserved it." The patient in this case had a good convalescence and showed only mild glycosuria between the fifth and nineteenth postoperative days and no further glycosuria till her death from recurrence of the carcinoma five and a half months later.

The fact that the patient enjoyed "perfect health" without evidence of diabetes until the recurrence of the carcinoma would seem to indicate from numerous reports on partial pancreatectomy on human patients that at least 10 per cent of the gland must have remained, regardless of whether or not

the small mass of tissue represented a supernumerary gland or an unresected portion of the head

Recently, Rockey² reported a case in which he performed total pancreatectomy for carcinoma of the pancreas, with widespread involvement of the gland. His patient survived for 15 days. Necropsy revealed less than 1 Gm of pancreatic tissue unresected.

Unless we have overlooked any cases, ours is the second authenticated case of total pancreatectomy for any cause ever reported, and the only case in which there was survival beyond the immediate postoperative period.

In March, 1942, Duff³ presented an extensive *Arbeit* on the "Pathology of Islet-cell Tumors of the Pancreas." From his review of the literature he was able to make the following statement: "The hypoglycemia syndrome has not been observed in association with islet-cell adenomata of a diameter less than 1 cm." The measurements of the adenoma in our case were 8 x 5 x 5 Mm. Smaller adenomas have been reported but they have been found incidentally at necropsy and were not associated with clinical hypoglycemia.

Total pancreatectomy in this case appeared to be justified by the following consideration. Careful examination of the gland at operation did not disclose an adenoma. It was then obvious that the hyperinsulinism was due either to an undiscovered adenoma or to hyperfunctioning of islet cells. Partial pancreatectomy would cure the patient if the resected portion contained an adenoma and might cure the patient if hyperfunctioning islets were the cause of the patient's symptoms, as in the case reported by Graham and Hartman.⁴ However, it has been our experience that partial pancreatectomy in cases in which islet-cell adenomas were not found has been disappointing and has required in some cases repeated resections without favorable results.

Total pancreatectomy, on the other hand, should remove the cause of hyperinsulinism whether it is due to an adenoma or to hyperfunctioning islet cells, and should not be followed by important disturbance of digestion and nutrition resulting from loss of external pancreatic secretion, as has been shown by the work of Whipple and Bauman⁵ in removing the head of the gland for carcinoma. The decision to remove the entire pancreas and to substitute for the incapacitating illness of hypoglycemia, diabetes and external pancreatic insufficiency, which we felt could be controlled fairly well medically, has been a happy one—an adenoma which would have been left behind if partial pancreatectomy had been performed was removed and the patient was cured of hyperinsulinism.

THE EFFECTS OF TOTAL LOSS OF INTERNAL SECRETION OF THE PANCREAS

The metabolic problem resulting from complete pancreatectomy resolves itself into two main considerations. First, a deficiency of the internal secretions of the gland, and, second, a deficiency of the external pancreatic secretions. It has been shown, both experimentally in animals and in cases of partial pancreatectomy performed upon human patients, that more than 80 to 90 per cent of the gland must be resected before diabetes mellitus is

TOTAL PANCREATECTOMY

produced In 1934, Graham and Hartman reported a case in which they resected 80 to 90 per cent of the gland for hyperinsulinism The patient was one year old No adenoma could be found in the resected portion of the pancreas Complete recovery was attained, and the fasting concentration of sugar nine months after operation was 83 mg per 100 cc of blood Other cases, in which the patients were adults, are reported in the literature in which as much as three-fourths of the gland has been resected and there appears to have been sufficient internal secretory function retained to prevent the occurrence of diabetes⁷ It was anticipated, of course, in our case that complete pancreatectomy would produce diabetes mellitus but we felt that this could be controlled adequately by diet and insulin The mild degree of the resulting diabetes was not anticipated

Our findings in regard to the degree of internal pancreatic insufficiency

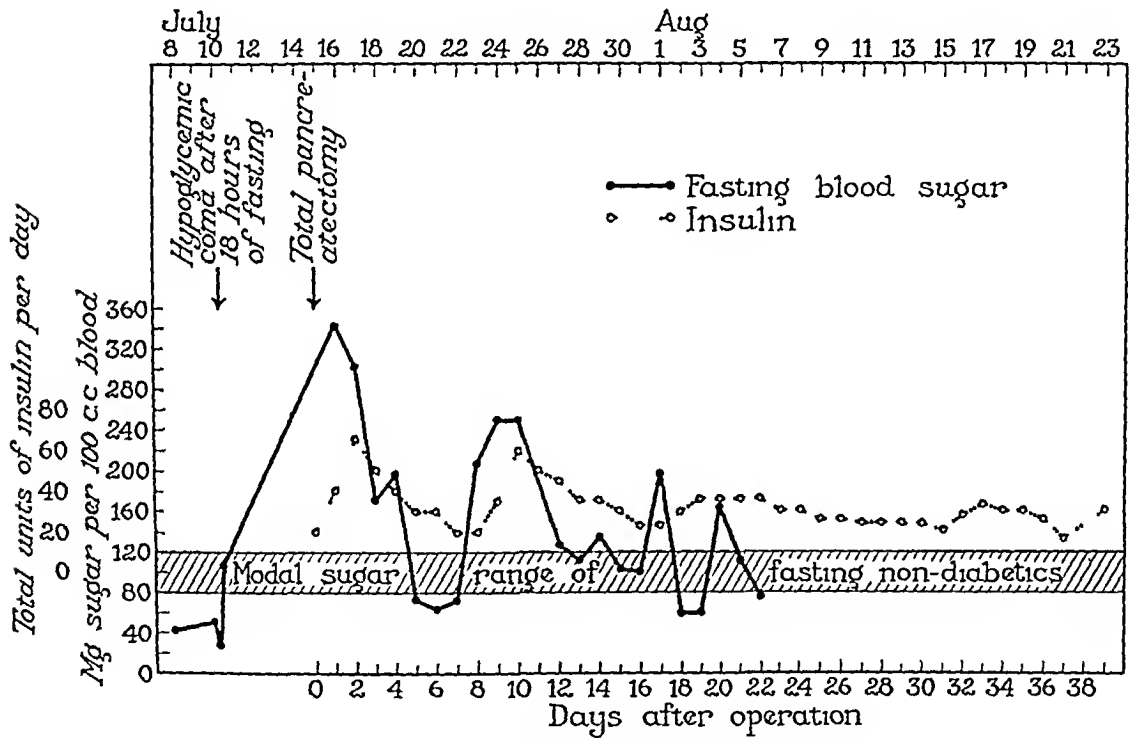


CHART 1—Fasting concentrations of blood sugar and insulin requirements before and after total pancreatectomy

are in close accord with those of Rockey in his recent report of total pancreatectomy for carcinoma During the 15 days of postoperative survival of his patient's insulin requirement leveled off at a range of less than 27 units per day

An interesting point was made in a recent article by Dragstedt⁶ that it is necessary to remove 90 to 95 per cent of the pancreas of a dog to produce diabetes The resulting diabetes, however, is very severe and, paradoxically, is more severe than if the total gland were removed There are no published data known to us on man to make a similar comparison However, in one case (unpublished) at the Mayo Clinic partial pancreatectomy was performed repeatedly for persistent hypoglycemia, and after the final

operation, which left only a small rim of pancreas adjacent to the duodenum, diabetes resulted which required between 60 and 100 units of insulin daily to control nearly one and a half years after operation. When this high insulin requirement is compared with the relatively small amount required to maintain control in Rockey's and in our case, after total pancreatectomy, the same paradox is noted as occurs in dogs.

As shown in Chart I, the fasting daily blood sugar reached a maximal height of 341 mg per 100 cc of blood on the morning after operation. The greatest total units of insulin required in any one day were 66. Regular, unmodified insulin was used for about four days after operation to "cover" the intravenous injections of 5 per cent solution of glucose in saline or distilled water. From about the fifth postoperative day the diabetes was controlled by single daily subcutaneous injections of protamine zinc insulin and regular insulin in a single combined dose, administered 20 minutes before breakfast. As will be noted in Chart I, the total daily dose that was required averaged around 30 units a day. The ratio of the two types of insulin varied from one unit of protamine zinc insulin to one to two units of regular insulin. The daily determinations of blood sugar were discontinued on the twenty-second postoperative day and the diabetes was controlled from this point on by testing the urine. Specimens of urine were obtained at 6 and 11 A M and at 4 and 9 P M. The specimens of urine tested were fresh specimens, that is to say, the bladder was emptied by voiding a half hour before each specimen was obtained for testing. By the time of dismissal from the hospital the patient had been taught a system of adjusting her own combined dose of insulin so that the specimens of urine taken before breakfast and before supper showed a trace of sugar. Thus, the occurrence of insulin reactions was avoided but the diabetes was kept in adequate control.

At the time that the patient was dismissed the results of analysis of stools and urine were not available, therefore, the patient was sent home on the diet of 1,965 calories, basal plus 50 per cent, composed of 243 Gm of carbohydrate, 94 Gm of protein, and 70 Gm of fat. No pancreatin was given. Adequate vitamin supplements were added. A letter received from her physician December 14, 1942, four months after her dismissal, stated that the patient was using "anywhere from 10 units of protamine zinc insulin and 10 units of regular insulin to 15 units of each every morning. She controls her dosage very well by checking her own urine. The urine is usually sugar-free. One month ago her fasting blood sugar was 109 mg per 100 cc. Two days ago her fasting blood sugar was 177 mg per 100 cc this being after some holiday dietary indiscretion." Another letter stated that the patient "is doing very well. Her fasting blood sugar, taken two weeks ago, was 134 mg per 100 cc. She uses just about the same amount of insulin. Her only complaint is severe abdominal cramps each morning." On July 16, 1943, her husband wrote that he was happy to say that "she is doing fine, has gained about three pounds (1.4 Kg), eats practically everything, and is in fine spirits. She is really enjoying life. She also does

not weigh her food. She still has cramps for two to three hours every morning, but they are not as severe as at first." The latest report we received was in November, 1943. The dose of insulin still varied between 20 to 30 units per day.

As it has been established experimentally that fatty metamorphosis of the liver and hypolipemia usually develop, ultimately, in dogs adequately maintained with insulin unless they are given adequate amounts of raw pancreas, lecithin, choline or the extract of the pancreas or lipocain,⁶ a diet rich in choline was given to our patient to prevent the development of a fatty liver and hypolipemia. Fifty grams of cottage cheese was a daily constituent of the diet and this, together with a high protein content, was considered adequate to prevent such changes. The excellent health of the patient 16 months after total pancreatectomy is indirect evidence that such developments have not taken place. It has not been possible to obtain studies of function of the liver since dismissal.

EFFECT OF TOTAL LOSS OF EXTERNAL PANCREATIC SECRETION ON DIGESTION AND ABSORPTION

On the twelfth postoperative day the patient was taking a rather liberal solid diet, and the diabetes was under control. At this time, studies were begun to determine the degree of utilization of carbohydrate, protein and fat, and were carried out during two ten-day periods and one five-day period. It is possible that data obtained at a longer interval after operation would reflect the ultimate effect of total pancreatectomy better than those obtained so soon after operation. It is felt, however, that the data obtained are sufficiently interesting to warrant recording them.

The patient's basal caloric utilization was 1,310 calories, as computed by the Boothby nomogram. The three periods were kept essentially isocaloric at basal plus 50 per cent. This equaled approximately 2,000 calories a day. The cooked food was weighed and the content of carbohydrate, protein and fat was estimated according to Sherman's tables. In the first ten-day period the estimated daily intake of carbohydrate, protein and fat was, respectively, 241, 94.5 and 69 Gm., in the second ten-day period the estimated daily intake of carbohydrate, protein and fat was, respectively, 206, 67.7 and 102.5 Gm. In the third five-day period the estimated daily intake of carbohydrate, protein and fat was, respectively, 222, 70 and 95 Gm. In the second and third periods the intake of protein was decreased approximately 25 per cent below the intake in the first period while the intake of fat was increased 25 to 30 Gm. over it. The intake of carbohydrate, protein and fat was essentially the same in the third as in the second period. During the third period the patient was given 4.5 ounces (140 Gm.) of powdered pancreatin (Parke-Davis) in gelatin capsules (0.9 ounce [28 Gm.] a day). Data obtained during the third period, which was terminated at the end of five days because of the patient's objection to pancreatin, are not as statistically significant because of shorter duration of the period as those obtained in the

TABLE I
AVERAGE DAILY VALUES FOR FECAL SOLIDS AND CALORIES INGESTED AND LOST

Period	Calories										Fecal Solids														
	Intake					Loss					% Lost			% Total as Fat and Protein											
	Carbohy- drate	Protein	Fat	Total	Fecal Fat	Fecal Nitrogen	Fecal Sugar	Total	Balance	Require- ments	Urine	Feces	Total as Fat	Fecal N as Protein Gm	% Total as Protein Gm										
I—10 days	962	378	621	1 961	433	71	207	00	32	64	673	35	1 287	7	1 310	34	131	97	48	19	37	51	75	39	76
II—10 days	825	271	923	2 019	326	52	101	64	10	88	439	04	1 580	1 310	22	83	94	36	28	43	25	41	30	73	
III—5 days	889	280	855	2 024	358	20	73	00	3	36	434	56	1 589	1 310	21	73	4	39	8	54	18	25	25	79	

TABLE II

AVERAGE DAILY VALUES FOR INTAKE AND LOSS OF NITROGEN AND FAT

Period	Nitrogen										Fat														
	Loss Gm					Intake Gm					% Intake Loss in					Loss in Feces Gm					% Intake Loss as				
	Urine	Feces	Total	Food	Pancreatin	Total	Gm	Balance	Urine	Feces	Neutral	Split	Total	Gm	Intake	Balance	Neutral	Acid	Fatty	Total					
I—10 days	5 27	8 28	13 55	15 12	0	15 12	+1 57	35	55	33	09	15 10	48 19	69	20 81	69	31	48	22	70					
II—10 days	5 88	4 07	9 95	10 83	0	10 83	+0 88	54	38	19	40	16 88	36 28	102 5	66 22	54	46	19	16	35					
III—5 days	5 50	2 92	8 42	11 20	0 66	11 86	+3 44	46	25	22	40	17 40	39 80	95	55 20	56	44	24	18	42					

first and second periods. A daily weight was obtained during the last 13 days of the study. This fluctuated within a range of three pounds (1.4 Kg). The daily average number of stools varied but little from period to period, being 2.4 on the low fat and 2.8 on the high fat diet with pancreatin.

Methods—The periods were begun and terminated by the use of carmine dye marker technic and feces and urine were collected for five-day periods. The stools were analyzed for total and neutral fat, nitrogen and carbohydrate, the urine for nitrogen and sugar. The total fat was estimated by the method of Saxon,⁷ neutral fat by the method of Saxon, nitrogen was estimated by the method of Kjeldahl, and carbohydrate by the method of Folin and Wu. The results are given in Tables I and II.

Fecal Solids—The average daily values for fecal solids are shown in Table I. The average daily weight of dried feces was greatest during Period I, when the loss of fat and nitrogen was greatest. The dried weight of the feces was greater than that of normal subjects on the standard Schmidt test diet, as reported by Pratt.⁸ He found that the average daily weight of the dried feces of a series of six normal persons over a period of three days was 54 Gm. and that the maximum was 62 Gm. The average daily values obtained in Period I were comparable to those obtained by Pratt (113 to 154 Gm. a day for a three-day period) in five cases of carcinoma of the pancreas with obstruction to the pancreatic ducts, while the values in Periods II and III were increased only moderately above those in healthy persons.

The fat composed 37 to 54 per cent of the fecal solids (range in normal persons 8.5 to 28.5 per cent, average 18.5 per cent), 54 to 69 per cent of the fecal fat was neutral fat. The daily loss of nitrogen in the stools varied from 2.92 to 8.28 Gm. Computing the fecal nitrogen in terms of protein, average daily fecal protein accounted for from 25 to 39 per cent of the fecal solids. Fat and protein accounted for 73 to 79 per cent of the fecal solids.

Reducing Substances in the Feces and Urine—Reducing substances in the feces were not measurable in Periods I, II or III. The average daily values for reducing substances in the urine are shown in Table I in terms of calories. These average daily values varied from 0.84 Gm. (3.36 calories) to 8.16 Gm. (32.64 calories).

Nitrogen Balance—The nitrogen intake and loss are shown in Table II. The greatest nitrogen loss was observed during the period of greatest nitrogen intake (Period I). The nitrogen loss was less during Period III than during Period II, although the intake of both protein and fat was essentially the same during the two periods. Pancreatin was given during Period III and the smaller daily loss of nitrogen during this period appears to have been due to the pancreatin, in spite of the administration of pancreatin in gelatin not enteric coated, capsules. The effect of this amount of pancreatin in gelatin capsules on the digestion of protein in this case accords with that of one of us (unpublished data of Comfort), and of Beazell, Schmidt and Ivy,⁹ and Rekers, Pack and Rhoads,¹⁰ on the effects of large amounts of

pancreatin given in enteric coated capsules in cases of external pancreatic insufficiency. The daily loss of nitrogen in the urine did not vary greatly in the three periods. The nitrogen balance was positive in Periods I and II despite a small loss of weight, but was more positive in Period I, in which the intake of nitrogen was greater than in Period II. The nitrogen balance was greater in Period III than in Period I, in spite of the greater intake of nitrogen in Period I. This may be due to the smaller daily loss of nitrogen in the stool and greater daily digestion and absorption presumably due to pancreatin.

Fat Values—The average daily intakes of fat and the total fat in the stool during the three periods are shown in Table II. The proportions of ingested fat that was lost in the stool were, respectively, 70, 35 and 42 per cent in Periods I, II and III. The average daily value for total fat lost was greater on the low fat (69 Gm.) diet than on the high fat (102.5 Gm.) diet. The average daily value for total fecal fat was approximately the same in Period III, when the patient ingested a daily average of 95 Gm. of fat plus powdered pancreatin in gelatin capsules, as in Period II. In short, pancreatin administered in this fashion did not affect the absorption and digestion of fat significantly, contrary to the unpublished data of one of us (Comfort) and published data of Beazell, Schmidt and Ivy and of Rekers, Pack and Rhoads, on the effect of large amounts of pancreatin in enteric coated capsules in cases of external pancreatic insufficiency. The variations of the amount of neutral fat lost in the feces paralleled those of total fat. The percentage of total fat as neutral fat was greatest in Period I (low fat period) while the percentages of total fat as neutral fat were approximately equal in Periods II and III with an equal fat intake, in spite of the administration of pancreatin in Period III. Pancreatin, as given, did not affect the digestion of fat significantly in this case.

The Effect of Loss of Food in the Urine and Feces on Caloric Balance—The caloric values of the ingested food and of the foods recovered in the urine and feces are given in Table I. The average daily caloric values of the foods ingested varied but little in the three diets. The loss of food in the urine was small, that in the feces was heavy. Metabolic fecal fat and nitrogen have been ignored in computing the balance. The average daily loss of calories was 673, 439 and 435, respectively, during Periods I, II and III and 34, 22 and 21 per cent of the caloric intake was lost during these same periods. The calories utilized were approximately equal in number to those for basal requirements during Period I and were only slightly in excess of basal requirements in the other two periods. The caloric loss was found to be great enough to affect the estimated necessary caloric intake radically.

SUMMARY AND CONCLUSIONS

A case of hypoglycemia due to hyperinsulinism from a small adenoma of the islets of Langerhans in which a total one-stage pancreatectomy was performed is reported herewith. A less radical procedure would have failed to

cure the patient, since the adenoma was located in the head of the gland, in intimate proximity to the duodenum. We believe that this is the first case of total pancreatectomy for benign or malignant disease in which the patient has survived beyond the immediate postoperative period. Total pancreatectomy was followed by a relatively mild degree of diabetes. Disturbance of carbohydrate digestion was not detected by the methods used, while digestion of protein and fat was definitely diminished. About 35 to 70 per cent of ingested fat and 25 to 55 per cent of ingested nitrogen could be accounted for in the feces. A positive nitrogen balance occurred in spite of the large loss of nitrogen in the feces. Foodstuffs in the urine and feces accounted for 21 to 34 per cent of the calories ingested. The percentage of total fat in the stools as neutral fat varied from 54 to 69 per cent. The dried weight of the stools was greater than values obtained for healthy persons. The patient has remained in excellent health, 16 months after the operation. Evidence of deficiency of lipocaine has not developed.

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TOTAL GASTRECTOMY, SPLENECTOMY, RESECTION OF THE LEFT LOBE OF THE LIVER, OMENTUMECTOMY AND COLECTOMY UPON ONE PATIENT IN ONE OPERATION

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A REPORT of the removal of the stomach, with resection of the left lobe of the liver, the spleen, omentum and entire colon at one operation, may seem only piffling, in view of the fact that the patient died after the second-stage closure of the Mikulicz anastomosis of the lower sigmoid and terminal ileum, five months after the original operation. However, a report of the case serves to illustrate modern progress in anesthesia and surgery and to demonstrate the amount of surgery a patient even of advanced years, in this surgical era can survive.

REPORT OF CASE

A male, age 66, was referred to the Lahey Clinic with a history suggesting carcinoma of the stomach, and a roentgenogram showing evidences of a tumor occupying a large

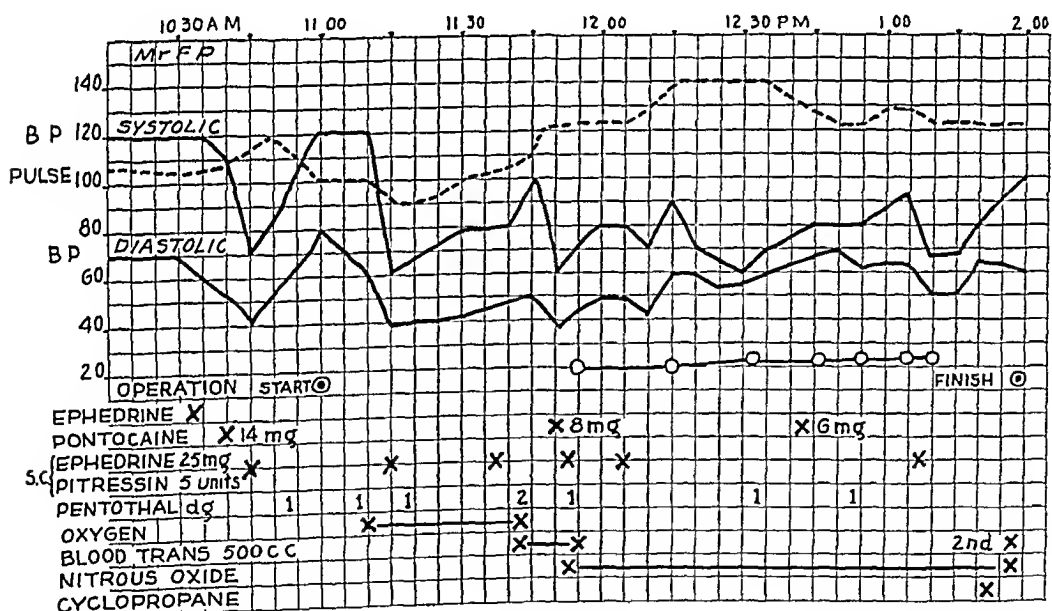


CHART 1—Showing the data recorded during the prolonged, continuous fractional anesthesia

part of the stomach. The diagnosis was probable carcinoma of the stomach, and he was submitted to surgery, with a prospect of total gastrectomy.

The operation was performed under fractional spinal anesthesia. The anesthesia record showing the time consumed, pulse and blood pressure is shown in Chart 1.

Upon opening the abdomen, the median portion was found to be occupied by a large firm mass assumed to be a carcinoma. Included in this mass by contact invasion was the left lobe of the liver.

MULTIPLE ONE-STAGE OPERATIONS

by contact extension was the midtransverse colon up to the splenic flexure. As the transverse colon was turned up to inspect the jejunal fossa, this extension to the transverse colon was found to reach into the mesentery of the transverse colon next to the bowel and to involve the middle colic artery. There was a considerable area of mesenteric root that was uninvolved.

While on first inspection the mass seemed hopelessly irremovable, further investigation revealed no nodes in the gastrocolic or gastrohepatic omentum, and no metastases in the liver except where the gastric mass had involved the left lobe of the liver by contact extension. The mass, which was freely movable and sharply demarcated, was

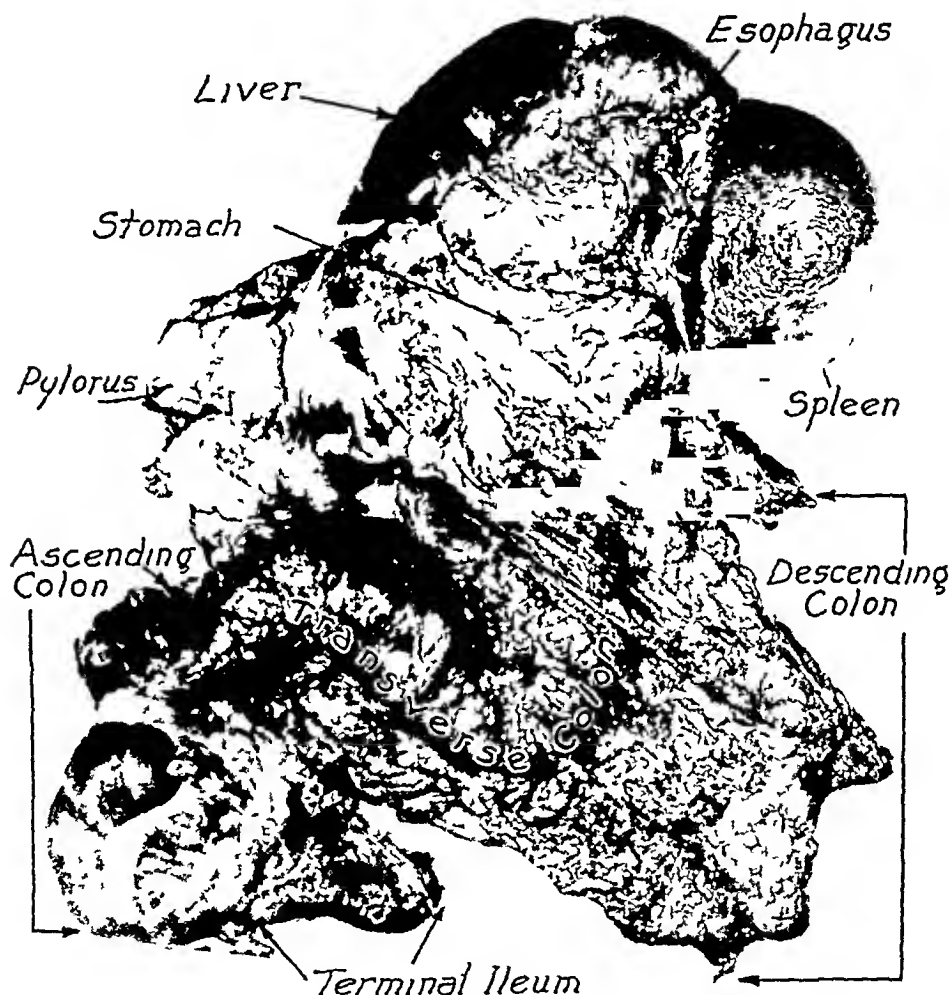


FIG 1—Photograph of the gross specimen of the composite mass of viscera removed

evidently of an unusual nature. Although apparently malignant, occupying a large portion of the stomach, it had not extended into the lymph nodes, and if one cared to accept the hazards of such an extensive procedure, it was removable. Although the patient was 66 years of age, he was thin and wiry, and preoperative study had revealed nothing abnormal except the gastric lesion. It was, therefore, decided to accept the risk.

Because the transverse colon with its middle colic artery was involved, it seemed best to transect the ileum, tie the blood supply and free the entire colon (ascending, transverse and descending) from the ileum down to the sigmoid, sewing the ileum to the sigmoid to make a Mikulicz anastomosis. The liver was cut across where the left lobe joins the right lobe, controlling bleeding with the fingers until mattress sutures of silk

could be inserted. The spleen was freed and turned up, its vessels were tied at the tail of the pancreas, and the whole block of organs, the left lobe of the liver, stomach, omentum, spleen and entire colon, was then removed in one mass. The duodenum was inverted and closed and the jejunum anastomosed to the esophagus as in any total gastrectomy.

In the interval between the original operation and the secondary closure of the Mikulicz anastomosis, the patient was driven by motor 250 miles to his summer home in the mountains. His weight was maintained but did not increase. Three months after operation the Mikulicz opening was successfully closed, but the patient died two months later due to what was proved by autopsy to be a recurrence of the malignant lesion. The pathologic report was Hodgkin's disease of the stomach.

COMMENT

On review of the case, the operative undertaking was not as reckless as it may appear to the reader. At the Clinic many total colectomies for ulcerative colitis and polyposis have been performed successfully. Splenectomy, likewise, has been undertaken in many total gastrectomies and adds but little to the time and the technical steps of the procedure. Resection of the left lobe of the liver is not a difficult technical undertaking since its ligamentous attachment to the diaphragm is avascular, easily detached and permits such mobilization of the left lobe that it readily can be severed from the right lobe and the bleeding accurately controlled by mattress sutures.

With the entire colon and omentum removed, together with the spleen, stomach and left hepatic lobe, the remaining abdominal contents, largely right lobe of the liver and small intestine, only partly filled the abdominal cavity and so made exposure and suture of the jejunum to the esophagus extremely easy. In fact, in none of the 73 total gastrectomies which have now been performed at the Clinic has the exposure been as complete, and the anastomosis as easy, as in this case after removal of all the organs that so often interfere with exposure.

The Mikulicz plan of anastomosis of the ileum to the sigmoid, the usual procedure in colon resections in this Clinic, lessened the time required for the anastomosis, eliminated any additional hazard of leakage, and permitted immediate decompression of the small intestine through the tube inserted into the ileac end of the Mikulicz anastomosis.

Without the excellent continuous spinal anesthesia provided by the Department of Anesthesiology of the Clinic, I doubt that this extensive operation could have been accomplished successfully.

SUMMARY

The patient described had the most extensive operation ever undertaken in my experience, namely, total gastrectomy, splenectomy, omentumectomy, colectomy, and resection of the left lobe of the liver. The technical surgical details are given, together with a photograph of the specimen and the anesthesia record. Although the removal of this large amount of abdominal contents was not justified in view of the short period of survival of the patient, the successful technical accomplishment of the operation is proof of the modern advances in anesthesia and surgical methods.

AN EXPERIMENT IN THE EARLY DIAGNOSIS OF GASTRIC CARCINOMA¹

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THE RECORD of the patients with carcinoma of the stomach at the Presbyterian Hospital, we believe, is not unusual. During the 35 years from 1908 to 1942, inclusive, 1204 people with carcinoma of the stomach were admitted to the hospital. Of this number 231 underwent resection, of whom 64 died as a result of the operation, leaving 167 who were discharged after radical surgery. Even this number includes a few cases in which the surgeon knew he left tumor behind, or the pathologist demonstrated unsuspected tumor cells at the limit of the resection. We face the fact, then, that of all the people who came to the hospital during this period with this condition less than 15 per cent left it with any possibility that their disease had been arrested.

There are several obvious means by which this record could have been improved, which we have attempted in recent years to employ: (1) A more alert attitude on the part of the internists into whose hands the patients usually come first, so that early carcinomas are less often overlooked. (2) Better technique on the part of the radiologists and gastroscopists in demonstrating suspected lesions. (3) Willingness on the part of the surgeons to operate when, after careful study, some suspicion of carcinoma still exists. (4) Wider resections, and resections of tumors formerly considered inaccessible. In our clinic, as in many others throughout the country, this is being done. (5) A lower operative mortality rate. Our rate has dropped from 33.8 per cent for the period 1908 to 1937, to 17.9 per cent for the period 1938 to 1942, and to 4.7 per cent for the year 1942.

We believe that all these factors have played their part in raising our resectability rate from 14.8 per cent for the period 1908 to 1937, to 36.5 per cent for the past five years. Before 1938, less than one patient in ten with gastric carcinoma left the hospital with any possibility of arrest of his disease, now during the past five years the ratio approaches three in ten. Whether this apparent improvement will result in more five-year survivors, there has not yet been time to tell. It will follow, probably, that the rate of arrest will not keep pace with the resectability rate but rather with another

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factor, namely, the proportion of cases that come to surgery free of metastases. Our reason for this belief lies in the following statistics. Of the 97 patients who survived resection prior to April, 1938, 25 (25.8 per cent) lived five years, or more, apparently free of their disease. This is a most encouraging figure, which shows that radical surgery for carcinoma of the stomach under proper circumstances does offer hope of cure. But it is significant that of these 25 survivors only four were shown to have metastases at the time of operation. When one recalls that these four were the sole survivors of about 900 with presumable metastases who were admitted during this period, the importance of early diagnosis becomes obvious.

This does not mean that the measures which were taken to improve our results have been futile. Certain advances have been made. The number of admitted cases who were found to have no metastases prior to 1938 was about 6 per cent, during the past five years it has been nearly 10 per cent. Of importance, too, is the fact that a greater proportion of cases without metastases have survived resection. Perhaps, also, more cases with metastases will prove to have been saved by the wider resections now being undertaken. In other words, we are providing our surgeons with a more hopeful group of cases, and they are being better treated. But it is still true that the great majority of cases enter the hospital already hopelessly ill, and it is within this group that improvements must be made if the death rate from carcinoma of the stomach among the general population is to be significantly reduced.

TABLE I
CARCINOMA OF THE STOMACH
1908-1942 (Inclusive)

	1908-1937	1938-1942	Total
Admissions	960	244	1204
Operations not for cure	471	95	566
Resections	142	89	231
Resection rate	14.8%	36.5%	19.2%
Resection operative mortality	33.8%	17.9%	27.7%
Metastases absent	56	24	80
Metastases absent (survived resection)	41	21	62

It is this large group which comes to the doctor too late for attempts to cure that is the main subject of our study. They come too late usually because the early symptoms of gastric carcinoma escape their notice or do not seem to them important. To them may be added, unfortunately, the patients whose gastro-intestinal studies were delayed because the doctor whom they first consulted failed to elicit complaints or appreciate their significance. Clearly, if the surgeon waits for these people to come to him, they will continue to come too late. Therefore, he must reach out and bring them in to study before they are aware of trouble, if possible while their disease is yet asymptomatic. Much has been done for pulmonary tuberculosis by mass studies of people who did not suspect that they had the disease, and we have made an experimental attempt similarly to attack gastric carcinoma.

DIAGNOSIS OF GASTRIC CARCINOMA

The attempt consisted of mass roentgenologic studies of men and women who were not suspected of having gastric lesions. The subjects of the study were people over the age of fifty who had no digestive symptoms of appreciated significance. It was impossible to limit the group precisely, because few people have no digestive symptoms whatever. In selecting our cases we tried to include only those people who ordinarily would not have received

CHART I

CARCINOMA OF THE STOMACH FOLLOW-UP RESULTS AFTER PARTIAL GASTRECTOMY LIVED 5 YEARS OR MORE WITHOUT EVIDENCE OF RECURRENCE

PATIENT	METASTASES	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	NO OF YEARS FOLLOWING OP
1 G R	0																																23
2 G A	0																																22
3 Z M	0																																20
4 F H	0																																9
5 J S	0																																20
6 Y G	0																																22
7 J S	0																																21
8 P K	0																																13
9 E F	0																																15
10 H M	0																																11
11 G B	+																																8
12 L B	0																																11
13 B S	0																																10
14 B M	+																																10
15 G F	+																																9
16 E K	+																																7
17 E B	0																																8
18 S A	0																																7
19 D V	0																																7
20 A W	0																																6
21 R C	0																																6
22 J J	0																																5
23 C W	0																																5
24 J J	0																																5
25 P V	0																																5

a gastro-intestinal study, so that if they had a gastric lesion it would not ordinarily have been discovered. Maintaining this prerequisite, we first studied patients from the Surgical Follow-up Clinic, who had been treated for conditions other than gastric. We endeavored subsequently to examine every person over the age of fifty who came to the hospital, whether as a patient or a relative or friend. It was not difficult to persuade most of these people to come for examination and they were usually happy and grateful to know the result. We saw little evidence of arousing undue fear of cancer. This part of the study really comes under the province of public health. Controlled groups such as members of large corporations or civic departments should be the easiest to handle.

The study is yet incomplete but the results are beginning to be of interest. Two thousand, four hundred and thirty-two persons have been examined, of whom 491 have been reexamined a year, or more, later, making a total of 2923 examinations. Nineteen cases have been deducted from this study because they were admitted to it in error, in that they had important gastric symptoms. This leaves a net of 2413 new cases that have been studied. Of these, three had proven unsuspected malignant gastric tumors, two of which were carcinomas and one of which was a lymphosarcoma. The inci-

dence of unsuspected malignant tumors found was, therefore, 124 per thousand. These three cases underwent subtotal gastric resection.

The method of study is essentially a rapid fluoroscopic examination of the stomach. It is based on the belief that an experienced roentgenologist rarely requires more than a minute to satisfy himself by gastric fluoroscopy that he is dealing with normal findings. No attempt was made during our rapid examinations to determine more than the one fact, namely, did the stomach show evidence of abnormality or did it not? If nothing abnormal was noted, the patient was dismissed. If any suggestion of abnormality was seen, the patient was brought back for further careful study at a later time. The examination was made in the erect position only, unless something suspicious was found in the fundus, in which case the patient was also examined prone. The first thousand cases received a single stomach film to check the rapid fluoroscopic examination, but, as nothing was found on any of the films that had not been noted at fluoroscopy, the films were thereafter omitted. Using the present routine, it is possible to examine as many as 40 patients an hour. The chief difficulty has been not the speed of the examination but the handling of the patients, guiding them back and forth from the dressing rooms, keeping them flowing steadily into the fluoroscopic room, *etc.* It has required two assistants and a stenographer to keep the examiner busy.

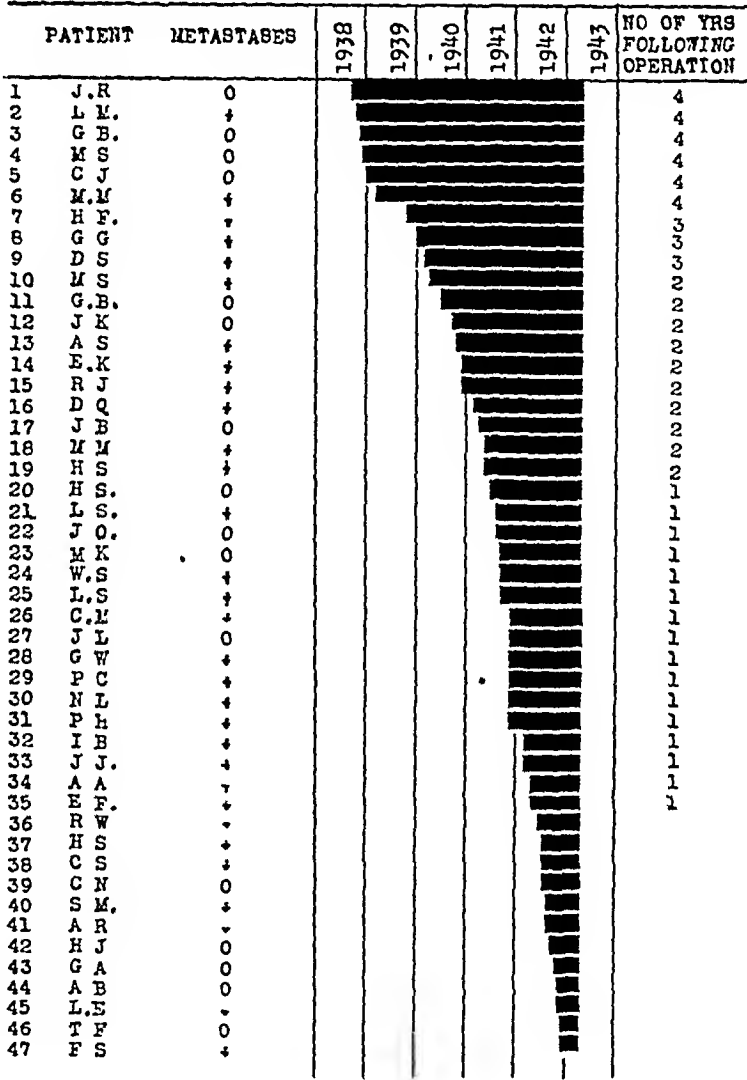
The objection has been raised to this method that, inasmuch as errors are frequently made at roentgenologic examinations of the stomach under the best circumstances, one might infer that so rapid an examination as we employ would lead to many more. It must be recalled, however, that at our rapid examination only one point is determined, namely, the presence or absence of an abnormality. Our experienced roentgenologists in their routine practice, over the years, have not required more time to make this determination, so that the rapid examination should in this respect be as accurate as the routine studies. Admittedly, the examination is as good as the roentgenologist, and no better. It must be done by someone with experience. One cannot expect perfection of the method. Only trial can tell how accurate it will prove to be, but even if it were only 50 per cent reliable it still might discover many early carcinomas that now go on to the inoperable stage. The study has not progressed far enough to prove or disprove the value of mass examinations of people in this manner. Unfortunately, the entire project is for the time being interrupted by war conditions. We are merely recording our findings thus far.

The most encouraging aspect lies in the three malignant lesions found and the nature of them. The first, a lymphosarcoma, was discovered at fluoroscopy because of a persistent area of flattening near the pylorus. This was confirmed by further roentgenologic studies, but at operation our senior surgeon was unable to appreciate any lesion even with the stomach opened and, therefore, did not resect. Some months later, at the site of the suspicious roentgenologic finding, an obvious tumor developed which was then resected and proved to be a lymphosarcoma. The patient later died of her disease. The note-

DIAGNOSIS OF GASTRIC CARCINOMA

worthy fact in this case is the discovery by quick fluoroscopic study of a lesion so small that an experienced surgeon could not appreciate it at operation The second case of malignant disease found was a double carcinoma of fungating type in the fundus of a 60-year-old man who came to the hospital

CHART II
CARCINOMA OF THE STOMACH
FOLLOW-UP RESULTS AFTER PARTIAL GASTRECTOMY
1938 - 1942 ALIVE WITHIN 5-YEAR PERIOD



because of a urethral stricture Slight gastric symptoms were present but had not attracted his attention A subtotal gastric resection was performed No evidence of metastases was found either at operation or at pathologic examination The third malignant lesion occurred in a man, age 54, who came to the hospital because of a large hydrocele This carcinoma was situated near the pylorus It presented an ulcerated area less than one centimeter in diameter The tumor had penetrated the muscularis mucosae and invaded the submucosa but had entered the muscularis only at one small area It had not metastasized This is one of the earliest gastric carcinomas ever found at the hospital

The nature of these three tumors has been a source of great encouragement to us. Two were very small when discovered, showing that tumors of this size can be discovered by our method. The two carcinomas which were found had not metastasized, which places them in the group of relatively good prognosis. There is no reasonable doubt that these three patients would have come to operation far later if they had been allowed to progress to the symptomatic stage.

There were five other cases who underwent gastric resection because of suspicion of gastric carcinoma but in whom only benign single or multiple ulcers were found. They were subjected to extensive roentgenologic study, and most of them to conservative therapy and gastroscopy before operation. Some of them had symptoms before being brought in for their first rapid fluoroscopy, but none had any intention of consulting a doctor about them. We have felt for some time that it is safer to resect stomachs in people over age 50, with persistent gastric ulcerations than to wait perhaps for a carcinoma to become all too obvious. One of the five died of a postoperative pulmonary embolus. The other four are symptom-free. These cases illustrate the difficulty in making an exact diagnosis in gastric lesions, even with all the diagnostic aids available.

An additional 15 cases were brought back for careful study because the first rapid fluoroscopic examination suggested some abnormality that might be due to a new growth. Their lesions were all considered to be benign, and were not subjected to operative exploration.

An interesting by-product of the study has been the relatively large number of abnormalities other than carcinoma that have been discovered. These include conditions both functional and organic. Five hundred and twenty-eight such instances were noted. The greater percentage, of course, were functional derangements. However, there was a surprising number of organic derangements. For example, 54 instances of deformed duodenal bulb were found, without symptoms of ulcer. Some of these had actual craters, but the majority showed the deformity of previous ulcers only. These were in people who "had never had any trouble with their stomach." There were seven instances of cardiospasm and 25 cases of diaphragmatic hernia, two of which were rather large. An idea of the incidence of other irregularities was obtained, such as anomalies of position of the stomach and duodenum, diverticula of the stomach and duodenum, evidence of "gastritis," *etc*. One polypus of the stomach was found. Ninety abnormalities within the thorax were noted and occasionally gallstones, *etc*.

The cost of the examination has been approximately 48 cents a person. This does not include the cost of the roentgenologist's services or the overhead charges for the roentgenologic equipment, but the actual cost of secretarial and technical help, stationery, films, *etc*. One of the chief difficulties has been to get people for examination as fast as we wanted them. While the method is still in the experimental stage, we have not been able to interest life insurance companies or city institutions in helping us to obtain

larger numbers of people for study. We have been limited to the people who have come to our own institution, although we could have well handled many times this number.

The study should be continued for many years to prove its value. We are particularly interested in seeing what evidence we can discover of the accuracy of the method. It is as yet too early to say what proportion of new growths we may have missed. Among the 491 people that we examined a year or more after their first examination, no tumors were found. We are aware of one error which happened on a morning when a junior roentgenologist was making the examinations and somehow overlooked a very large and obvious growth. The case is not included in our series because the patient had severe symptoms but we must, in honesty, make mention of it. Otherwise, so far as we know we have missed no tumors.

Whether this method is a practical one for reducing the large number of incurable gastric carcinomas that come to our hospitals we cannot yet say. At least one thing should come of it if nothing else, and that is an opportunity to learn more about the characteristics of early gastric carcinoma, for our experience so far has, unfortunately, been chiefly with its late manifestations.

THE FREQUENCY AND FUTURE OF GALLSTONES BELIEVED TO BE QUIESCENT OR SYMPTOMLESS*

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ALTHOUGH A NUMBER of objections to a general exploration of the peritoneal cavity as a routine part of an abdominal operation can be brought forward, an investigation of the region of the gallbladder, when permissible, is often more informative than is the invasion of the other quadrants.

The palpation of the gallbladder in an additional 150 cases during the course of abdominal operations performed upon women for conditions other than those relating to this structure, now makes possible a review of a series of 500 personal cases in which this procedure has been carried out.¹

By direct palpation of the gallbladder through celiotomy incisions in 500 women, stones were found to be present in 50, or ten per cent of the cases so examined.

This investigation presented two attractive opportunities. First, to contribute something toward establishing what may be accepted as the percentage of occurrence of gallstones in women, and then to attempt to gather some authentic information as to so-called quiescent or symptomless gallstones.

To discover the presence of gallstones in as many as ten per cent of 500 women not supposed to possess them at the time of discovery would seem to call for comment at least, if not explanation. However, there is good reason to believe that the actual percentage of occurrence among these women may have been even higher. As the stones in each case were discovered by direct palpation, it is probable that there were very few, if any, instances of mistaken identity. On the other hand, it would be quite remarkable if there were no stones present that escaped detection among 500 gallbladders palpated, and for good reasons. It is common experience to find small stones present in a gallbladder when opened after removal that had not been detected during the course of the operation. In the great majority of cases included in this series the gallbladder was examined through a lower abdominal incision, this definitely limiting the facility of examination. Conditions of or about the gallbladder itself, such as adhesions, a large and tense gallbladder, a bladder wall thickened and more or less rigid from chronic inflammation, or one or more small stones floating about in a considerable amount of bile either in the fundus or deep down in the ampulla, at times favored failure to appreciate a stone or stones present.

Allowance must also be made for the fact that this investigation was

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carried out in women only, most of whom had had pregnancies, and most of whom were at an age when biliary disease is most commonly experienced

Furthermore, there is no evidence to support an opinion that the various conditions bringing these patients to operation had had a share in the conditions resulting in the formation of the stones discovered

When all the many factors involved have been brought forward and duly considered, and such allowances and adjustments made, as may be necessary, it is probable that the ten per cent incidence of occurrence of gallstones in this group of 500 women would be duplicated in another group similar in size, in nationalities and social status, in ages and in conditions of child-bearing, and that in both it would closely approximate reality

Merely to find stones in 50 women not supposed to possess them before discovery, does not, without additional information and study contribute materially to existing knowledge as to so-called quiescent or symptomless gallstones

A tendency to concentrate too much upon the condition presenting itself for operation and to omit entirely other inquiries into the past history, sometimes resulted in failure to bring into the picture information that might have suggested the occurrence of biliary disease either as an episode of the past or as an existing complication

When the histories of some cases were supplemented following the discovery of the stones, it was found that not infrequently there had been evidences of their presence which were made more or less apparent in one of three ways. There may have been symptoms so slight as to be considered of little or no significance and readily accounted for by indiscretions of diet, indigestion or other common causes. There may have been one or more suggestive or typical attacks in the more or less remote past neither voluntarily reported nor previously inquired into. Finally, it became clear that some patients were actually having gallbladder symptoms at the time, which were erroneously attributed to, or more or less obscured by, the surgical condition obviously present

In a consideration of the potentialities of inactive gallstones, a useful distinction can be made between those that have asserted their presence on one or more occasions, but at intervals of considerable duration, and those that have never caused symptoms, so far as can be determined, applying the term quiescent to the former variety and symptomless to the latter. Among the 50 patients composing this group of cases there have been satisfactory examples of each type, many more of the first than the second

It is disappointing that the sources of knowledge as to inactive gallstones are so few and that these are unsatisfactory, since, for the most part, they seem to withhold at the same time that they contribute much valuable information. Many such stones undoubtedly exist and escape detection altogether, while others, even though discovered, are of entirely known duration and still others are promptly removed, thus terminating a possible chance to observe future behavior

The plain roentgenogram occasionally shows a stone or stones not previously suspected of being present. But it is not possible to demonstrate the presence of the great majority of gallstones in this way.

Not unnaturally, cholecystograms are rarely if ever resorted to in the absence of suspicions regarding the gallbladder, while as to the many instances of unsuspected gallstones found in the gallbladder at autopsy, the absence of reliably recorded gallbladder symptoms does not justify the assumption that there had not been such at any time prior to the demise of the individual found to possess them.

It is probable that there is no better opportunity available at the present time to establish instances of quiescent or symptomless gallstones than by the digital examination of the gallbladder through the abdominal incision. Thus found, it is often possible to combine a careful past history with the developments of the future in an endeavor to isolate cases that can be accepted as instances of one type or the other.

It would seem that the discovery of the presence of gallstones with the abdomen already opened might be followed by the removal of the gallbladder in a majority of the cases. There were several reasons why this policy was not adopted.

Biliary disease not having been suspected before operation, it had not been discussed with the patients and consent to operation upon the gallbladder had not been obtained should this be indicated.

The great majority of the incisions were made in the lower half of the abdomen and there was reluctance to resort to either an undesirable extension of the existing incision or to add a second incision.

In many cases the condition bringing the patient to operation was quite sufficient, in itself, without superimposing a second major operative procedure, with its additional risks.

Over and above all of these considerations was the feeling that the presence of gallstones requires more than the mere removal of the gallbladder. The initial operation upon the biliary system offers the most favorable opportunity to deal satisfactorily, and usually finally, with the individual type of the disease present, and demands a suitably located incision, an adequate exposure, a thorough search for, and examination of, such biliary pathology as may be present, as well as an inspection of adjacent and associated structures, and an unhurried and carefully performed operative procedure adapted to the particular requirements of the individual patient.

In the few cases where the gallbladder was immediately removed, there was either an error in diagnosis and the gallbladder being the sole offender and the only lesion present, or, combined with the pathology that had been the operative indication, it was suspected of being responsible for an important part of, or perhaps all of the patient's complaints.

The reactions of the various patients when informed as to the presence of their gallstones were variable, as might have been expected. Some welcomed the news as an explanation or confirmation of occurrences of

the past, some, having just experienced a generous dose of surgery, were considerably distressed, while still others were apparently incredulous or made light of their condition, having undoubtedly been quite free from impressive symptoms in the past, a circumstance that would assist in explaining the unexpected discovery of the stones

Surprisingly few seemed to entertain the idea that there was need or reason to be relieved of their stones. Almost without exception the patients were informed at a suitable time as to the presence of the stones. In the absence of contraindications the removal of the gallbladder was not merely recommended but advocated. In surprisingly few cases was this advice accepted, only the onset of acute symptoms in most instances being persuasive, and even this often only after surprisingly long periods of delay. The reluctance to agree to operation was undoubtedly often due to the fact that the majority of the stones had produced few or no really urgent symptoms to emphasize the announcement of their presence, or there had been but a single and almost forgotten attack in the remote past.

The majority having declined operation upon their gallbladders after the facts had been placed before them, the desirability of establishing and continuing contact with each of these patients possessed of gallstones was quite obvious, and this was done so far as possible, for variable periods up to 20 years or more.

These composed a most favorable group to look to for possible information as to quiescent or symptomless gallstones, and were followed with particular zeal for this reason rather than that many of them were expected to eventually come to cholecystectomy.

An effort was made to discover among the members of the group a few cases at least that might be termed symptomless gallstones and still others that might be regarded as quiescent. As was expected, a number of patients sooner or later did develop the necessary symptoms to bring them to operation, while almost at once, two problems presented themselves as to some of the others. Knowing of the presence of the stones it became necessary at times to distinguish between minor digestive disturbances that would have been considered insignificant in other individuals and accounted for by the usual common causes, and identical complaints that had their origin in the gallbladder pathology itself.

Again, in a few cases, it was difficult, even sometimes impossible, to feel assured of the entire absence of symptoms that might be legitimately related to the gallbladder, even after the most careful, indirect and frequently repeated questionings.

It is at times no mean accomplishment to formulate an unambiguous question, to convey this to, and have it clearly comprehended by, the individual to whom it is directed and then to receive in return a precise and convincing answer.

This fact became particularly apparent when the necessity of obtaining

precise and essential information was found to depend almost exclusively upon the processes of interrogation

Only six of the original 50 cases can be listed as having been both free from all symptoms since the appreciation of the stones and as having remained under observation up to the present time

Two of these give a past history of doubtful accuracy, certainly, sufficiently so to disqualify them for listing as never having had symptoms

One other had had quite definite symptoms in the past, and one might have had symptoms mixed with those of a gastric ulcer

Two cases, having been under observation for periods of 9 and 15 years, were sufficiently clear-minded and responsive to give satisfactory assurance as to the entire absence of all gallbladder symptoms in their past histories, and having been equally free from all symptoms while under observation

A number of instances of long periods of quiescence of gallstones were discovered among the 50 gallstone cases. Apparently, it is not uncommon for a single typical attack to occur and then be followed by such a long period of freedom from symptoms as to create the impression that it was the final one. This seems to be a phase of the natural history of gallstones that is not uncommon and is generally recognized

In order to obtain additional information as to the condition of the gallbladders of some of the patients found to possess stones and perhaps confirm the findings of cholelithiasis, roentgenologic examinations were made in such cases remaining under observation as were willing to cooperate in this investigation and where conditions permitted. There were ten of these, eight having cholecystograms and two plain films

In four of these cases it was found that the gallbladder did not fill with the dye and that the gallstones were not visualized. These cases had gone for 10, 14, 18 and 21 years, respectively, since the discovery of the stones, two of the four having had symptoms at some time or other during the period (Cases 1, 6, 17 and 18)

In three cases the dye entered and left the gallbladder, the stones being demonstrated in each case. One of these examinations was made two weeks after the discovery of the stones, the patient apparently having mild symptoms, another five years after the discovery of the stones, there having been no symptoms, and the third, 13½ years after the discovery of the stones, there never having been any symptoms (Cases 23, 34 and 47)

In one case the dye did not enter the gallbladder but the stone could be seen four years after its discovery, there having been mild, though definite, symptoms in recent months (Case 37)

In two cases the presence of the stones could be shown in the plain film, three and one-half and six years, respectively, after their detection, the former case having had no symptoms, the latter having had annoying and persistent digestive disturbances the greater part of the entire period (Cases 35 and 50)

SYMPTOMLESS GALLSTONES

The relation of typhoid fever to this group of cases, and especially to the cases found to have gallstones, was of considerable interest. Two hundred fifty-nine of the 500 patients were questioned as to typhoid fever and 13, or five per cent, declared that they had had this disease. Of the 50 patients found to have stones, 40 were asked as to an attack of typhoid fever in the past, and four said that they had had this disease. Therefore, of the 40 patients that had had gallstones four had had this condition subsequently to an attack of typhoid fever and 36 had gallstones without there being a history of such an occurrence in the past. It should be noted that of the 13 patients among the 259 questioned as to typhoid fever nine had had this disease, but had not developed gallstones subsequently. Therefore, twice as many cases that had had typhoid fever escaped gallstones as had had typhoid and developed them.

Several topics related to this investigation present themselves for comment.

TABLE I

500 CASES IN WHICH THE GALLBLADDER WAS EXAMINED BY PALPATION DURING OPERATION, GROUPED BY DECADES AND SHOWING INCIDENCE OF OCCURRENCE OF GALLSTONES

Decade	10-19	20-29	30-39	40-49	50-59	60-69	Totals
Gallbladders explored	4	100	195	152	33	16	500
Stones present	0	7	13	20	5	5	50
Approximate percentage of occurrence of stones	0	7	6.25	13	15	31	10

TABLE II

OPERATIVE CONDITIONS IN 500 CASES IN WHICH THE GALLBLADDER WAS EXAMINED BY PALPATION DURING OPERATION

The Uterus	Uterine fibroids	193
	Uterine displacements fibrosis of uterus cancer of uterus etc	112
The Uterine Adnexa	Ovarian cysts inflammations of the tubes tubal pregnancies	102
Other Conditions	Incisional and umbilical herniae cancers of the colon, exploratory operations	93

Palpation of the gallbladder through the operative abdominal incision, while often affording information of value to both doctor and patient, should be employed with restraint and limited to suitable cases.

Undoubtedly, with increasing familiarity with the procedure the disturbance to the patient in accomplishing it is reduced, and considerable skill is acquired both in appreciating stones that may be present or, on the other hand, and determining with a reasonable degree of confidence that there is none.

While it seems that a small and solitary round stone may remain in the gallbladder at times without either producing symptoms or effecting pathologic changes in the gallbladder wall, very few cases among all those in this group have entirely escaped the consequences of retaining their stones. Very good and numerous reasons can be presented for the removal of the gallbladder found to contain stones. There is high probability of the eventual development of trouble, which, as in one case, may come in the

form of an acute gangrenous gallbladder and as the first manifestation of the presence of the stones

As the individual possessing gallstones grows older the risks of cholecystectomy increase, as does also the extent of the pathology involving the biliary system

SUMMARY

The final disposition of the 50 cases found at operation to possess gallstones can be given as follows Six received immediate treatment for their gallstones, eight died more or less promptly, 12 sooner or later returned for removal of their gallbladders, 12 were lost contact with after various periods of observation, and 12 remain under observation at the present time

Only two cases are presented as presumably examples of symptomless gallstones, and these from a fairly large group of cases representing biliary disease in its milder, intermittent or even completely unassertive varieties

Numerous cases of quiescent gallstones were discovered, varying greatly in duration and judged by the period of time elapsing between the occasion of the discovery of the stones and the last preceding attack, or a subsequent attack, or both

A brief review of each of the individual cases composing the group, with details of interest, follows

Five cases found to have gallstones had cholecystectomies at the time of the discovery of the stones* Two cases were errors in diagnosis, two had gallbladder symptoms complicating their operative conditions, one had apparently never had symptoms caused by the existence of the gallstones

Case 4—G W, age 23 at time of operation, September 19, 1921 Married and three pregnancies Operation Ventrosuspension, appendicectomy The gallbladder, found to contain an assortment of stones, immediately removed Owing to patient's age and the displacement of the uterus, the possible significance of 19 months of indigestion since the birth of her second child was not appreciated until the gallstones were discovered

Case 7—R A, age 32 at time of operation, May 1, 1923 No typhoid Married and five pregnancies Diagnosis, chronic appendicitis, based upon four definite, though mild attacks, involving the right lower quadrant during the preceding two months There had been no digestive symptoms between attacks and the presence of gallstones was not suspected until found at operation Gallbladder and appendix removed

Case 19—L F, age 35 at time of operation, November 26, 1927 No typhoid Single An exceedingly obese patient Operation Excision large ovarian cyst Seven large gallstones discovered in the gallbladder, which was removed As there had been no symptoms that could be related to the gallbladder, the stones could be regarded as coexistent or even symptomless

Case 24—R B, age 36 at time of operation, July 19, 1929 Had typhoid Married and two pregnancies Exploratory celiotomy for large tumor arising from pelvis, thought to be cyst or fibroid A six-months fetus, with hydramnios was found The gallbladder was found to contain a large number of small stones, and was then suspected

* In making up a group of the cases found to have stones, numbers were assigned to the cases in the chronologic order of their discovery These numbers are retained in the subdivisions of the group

of being the cause of the lower abdominal pain, although uterine complications could not be excluded Gallbladder removed

Case 31—M S, age 23 at time of operation, October 22, 1931 No typhoid Married and two pregnancies Operation for what were believed to be symptom-producing adhesions in right lower quadrant following appendicectomy Gallbladder found to contain stones Review of the history makes it doubtful that the appendix was ever affected Misinterpretation of the symptoms caused by the gallstones resulted in an error in diagnosis in each instance Gallbladder removed

One case, found to have a solitary gallstone, was treated by opening the gallbladder, removing the stone and closing the gallbladder at the time of the discovery of the stone

Case 22—M C, age 49 at time of operation, March 23, 1929 No typhoid Married and six pregnancies Hysterectomy for uterine fibroids The gallbladder was found to contain a solitary small stone The gallbladder was opened, the stone removed, and the incision in the gallbladder closed with some difficulty because of a thin and friable wall For the 12 years since the operation the patient has complained only of occasional spells of gastric acidity, with some gas This condition had also been present for a year or so preceding operation However, the symptoms described are insufficient either in degree or type to be definitely related to the gallbladder or to suggest a recurrence of the stone

Eight cases found to have gallstones were lost to this investigation because of death, five of these dying within a month, two under two years, and one surviving over five years Four had had no gallbladder symptoms, so far as known One had gone 21 years without an attack and one for seven years Two had had symptoms at intervals for 7 and 14 years, respectively, preceding discovery of the stones

Case 14—M H, age 49 at time of operation, February 7, 1925 Married and one pregnancy Operation for malignancy of the uterus Gallbladder contained a large solitary stone Patient died 20 months later, apparently never having had symptoms due to the presence of the stone

Case 26—C L, age 56 at time of operation, September 9, 1930 Married and one or more pregnancies Operation for cancer of cecum with obstruction The gallbladder contained a solitary stone size of a hickory nut So far as known there had been no symptoms in the past referable to the gallbladder, the patient dying four days after operation

Case 29—M N, age 62 at time of operation, May 2, 1931 No typhoid Married and two pregnancies Exploratory celiotomy for cancer of the uterus, found to be inoperable Gallbladder found to contain one and probably more stones Upon inquiry into the patient's past it was found that there had been an attack of gallstone colic in 1910 which lasted two days, followed by jaundice Patient died one month following operation, apparently having lived for 21 years, or more, without the recurrence of symptoms referable to the gallbladder

Case 30—M S, age 46 at time of operation, September 21, 1931 Married and one or more pregnancies Operation for fibrosis of uterus Gallbladder found to contain a cluster of small stones After operation it was learned that patient had had a definite attack of right upper quadrant pain, with vomiting, 14 years before, followed by other attacks at intervals The discovery of the presence of the stones resulted in additions to the patient's past history that should have been on record before operation, but

were omitted because of the urgent symptoms that brought her to the hospital. Patient died of complications on second day following operation.

Case 32—M F, age 65 at time of operation, July 22, 1932. No typhoid. Married and two pregnancies. Operation: Excision of malignant cyst of left ovary. Gallbladder contained 12 or more small round stones. Patient lived five months without gallbladder symptoms, nor had there been, so far as is known, any such symptoms at any time in the past.

Case 40—C G, age 62 at time of operation, June 3, 1935. Married, and one or more pregnancies. Operation: Cecostomy for malignancy of ascending colon with obstruction. Upon palpation, the gallbladder was found thickened and contracted about three round stones. Patient survived operation six days, and autopsy confirmed the observation made at the time of operation, three large stones being disclosed. A past history of seven years of indigestion that had not seemed particularly relevant before operation was thus probably accounted for.

Case 45—K O'C, age 34 at time of operation, August 17, 1936. No typhoid. Married and five pregnancies. Operation: Excision of cancer of cecum, and anastomosis. A stone the size and shape of a small olive felt in the gallbladder. Patient died on the 8th day after operation. The presence of the stone was confirmed at autopsy, the biliary passages being open and apparently normal. Apparently the only symptoms complained of had been those ascribed to the developing tumor of the large bowel.

Case 46—F K, age 62 at time of operation, May 6, 1937. No typhoid. Married and no pregnancies. Hysterectomy for adenocarcinoma of the uterus. The gallbladder was found to contain two marble-like stones. Inquiry after operation revealed that for a period of two years, beginning some five years previously, there had been several typical attacks of biliary colic. The patient died in July, 1942, there having been eight years without symptoms, three before and five after operation.

Twelve cases found to have gallstones subsequently came to cholecystectomy, having sooner or later developed acute symptoms—four during the first year following the discovery of the stones, four during the second year, and four at intervals of 8, 6, 5 and one-half and 2 years and ten months, respectively.

Case 8—R G, age 28 at time of operation, May 8, 1923. Had typhoid. Married and one pregnancy. Operation for excision of large ovarian cysts. Gallbladder found to be packed with stones. After two years patient developed acute gallbladder symptoms and cholecystectomy was performed elsewhere.

Case 10—S C, age 22 at time of operation, December 21, 1923. No typhoid. Married at 15, three pregnancies. Operation for advanced bilateral adnexal disease. Gallbladder felt to be filled with stones. A period of three years without symptoms was followed by five years of severe intermittent attacks. Cholecystectomy, October 5, 1931, eight years after discovery of the stones.

Case 11—L A, age 51 at time of operation, March 13, 1924. No typhoid. Married and ten pregnancies. Hysterectomy for uterine fibroids. Gallbladder contained numerous stones. Patient ridiculed the announcement as to the presence of stones, disclaiming all symptoms. Nine months later developed first acute attack. Attacks recurring, the gallbladder was removed November 29, 1925.

Case 12—B C, age 29 at time of operation, November 29, 1924. No typhoid. Married and one pregnancy. Operation for excision of ovarian cyst. Gallbladder found to contain numerous stones. Following operation it was learned that patient had been under medical care for mild but persistent indigestion for some time. Chole-

SYMPTOMLESS GALLSTONES

cystectomy March 10, 1925, with most satisfactory results Nineteen stones found in the gallbladder

Case 15—L H, colored, age 51 at time of operation, May 4, 1926 No typhoid Married and one pregnancy Hysterectomy for large uterine fibroid A large solitary stone felt in ampulla of gallbladder Three months after operation digestive symptoms developed After another eight months attacks of pain came on and increased Cholecystectomy March 13, 1928

Case 27—H H, colored, age 22 at time of operation, October 20, 1930 No typhoid Single Operation for excision of large ovarian cyst Several stones felt in the gallbladder Two years after operation there was pronounced fat intolerance During next four years digestive disturbances greatly increased Cholecystectomy October 26, 1936, six years after the discovery of the stones, with great benefit

Case 36—H B, age 37 at time of operation, March 13, 1924 No typhoid Married, no pregnancies Operation for excision of large ovarian cyst Gallbladder felt tense but no stones were detected An incisional hernia was repaired May 17, 1930, the gallbladder was not explored On January 22, 1934, ten years after the first operation, the hernia was again repaired and a stone the size of a marble discovered in the gallbladder The gallbladder was removed, July 31, 1934, following an acute episode of typical symptoms, with jaundice

Case 38—M K, age 37 at the time of operation, June 11, 1934 No typhoid Married and 12 pregnancies Repair of a rather large epigastric hernia Sole complaint had been the swelling of 12 years duration The gallbladder contained many small stones Following operation it was learned that during the last pregnancy, terminating three months previously, patient had been slightly jaundiced Patient soon developed crampy epigastric pains radiating to the back, and fat intolerance The gallbladder was removed September 27, 1934, and contained 89 faceted stones

Case 39—A O, age 54 at time of operation, August 23, 1934 No typhoid Married and three pregnancies Repair of perineum and ventrofixation Several faceted stones discovered in gallbladder Six months later patient developed attacks of upper abdominal pain, and these increasing, the gallbladder was removed May 15, 1935

Case 42—J M, age 43 at time of operation, August 13, 1935 Had typhoid Married and no pregnancies Operation for obstructing postappendectomy adhesions Several large faceted stones felt in the gallbladder Six months later there was recurrence of abdominal pains, but without obstruction and presumably of gallbladder origin Gallbladder removed February 4, 1937, with most satisfactory results

Case 44—F S, age 61 at time of operation, May 27, 1936 No typhoid Single Hysterectomy for cancer of the body of the uterus A number of small stones felt in the gallbladder So far as could be determined patient never had gallbladder symptoms until the onset of an acute attack three days before the second operation, April 28, 1938, when a gangrenous gallbladder was removed filled with *Streptococcus viridans* pus and disintegrated stones Recovery

Case 47—E H, age 37 at time of operation, August 28, 1937 No typhoid Married and one pregnancy Salpingectomy for chronic pelvic inflammatory disease following her confinement in March, 1936 Gallbladder contained numerous small stones There had been digestive symptoms for several years preceding the pregnancy Seen at intervals for five years, patient continued to complain of general abdominal pains, which finally developed into definite attacks of gallbladder colic After six months of attacks, that increased in frequency and intensity, the patient submitted to cholecystectomy March 13, 1943

Twelve cases found to have gallstones were sooner or later lost contact with Six were free from gallbladder symptoms when last seen Two of these had been followed for five years or more, two for four years, the other two

for three and one-half years and ten weeks, respectively. Three were having symptoms when last seen, and three disappeared too promptly after the discovery of the stones to permit observation.

Case 2—C G, age 40 at time of operation, June 4, 1921. Married and eight pregnancies. Operation for excision of large ovarian cyst. Gallbladder found filled with stones. Inquiry into patient's past history failed to elicit complaints that might be referred to the gallbladder. Patient could not be found following completion of convalescence.

Case 3—V C, age 40 at time of operation, August 6, 1921. Married and seven pregnancies. Hysterectomy for uterine fibroids. Gallbladder felt to contain stones. Upon investigation following operation it was learned that patient had had occasional attacks of epigastric pain, presumably, but not too clearly, due to her gallbladder. Could not be found following completion of convalescence.

Case 5—V A, colored, age 38 at time of operation, February 25, 1922. Married and one pregnancy. Hysterectomy for an unusually large uterine fibroid. Gallbladder was found to contain eight stones. History had recorded frequent belching of gas which was attributed to, and may have been due to the presence of the abdominal tumor. Patient was followed for five years after operation, without occurrence of gallbladder symptoms during this period.

Case 9—M B, age 43 at time of operation, May 31, 1923. Married and ten pregnancies. Operation for repair of umbilical hernia. A solitary round stone the size of an ordinary marble was found in the gallbladder. For one year preceding operation patient had complained of abdominal pain, which was attributed to the hernia, and presumably correctly so since patient was followed for four years after operation without occurrence of gallbladder symptoms before being lost sight of.

Case 13—C M, colored, age 41 at time of operation, January 27, 1925. Single. Hysterectomy for large uterine fibroid. Gallbladder found to contain a large stone impacted in the ampulla. Two years of increasing indigestion and attacks of abdominal pain had been attributed to the large and growing tumor. There was relief of symptoms for six months after operation and then recurrence with greater severity. After nine months of persisting symptoms patient finally agreed to operation, and then suddenly disappeared.

Case 18—F H, age 46 at time of operation, April 9, 1927. No typhoid. Married and five pregnancies. Hysterectomy for fibrosis of uterus. Gallbladder was found to contain a large solitary stone and probably smaller stones. Inquiry revealed that patient had been jaundiced during her last pregnancy five years before. Six months after operation patient disappeared for nearly ten years, reappearing in April, 1937, because of a prolapse. At this time she was having, and had had for the past six months, indigestion, gas and fat intolerance, and inability to manage a full meal. Refusing cholecystectomy, the prolapse was repaired. After ten months, free of all symptoms, she again disappeared.

Case 20—M P, age 48 at time of operation, April 7, 1928. No typhoid. Married and one or more pregnancies. Hysterectomy for uterine fibroids. The gallbladder contained numerous small stones, mostly in the ampulla. Inquiry after operation failed to establish a history of attacks of pain or digestive symptoms that might be due to the presence of the stones. Patient disappeared at the termination of her convalescence.

Case 21—C R, age 43 at time of operation, September 27, 1928. Married and three pregnancies. Typhoid fever when 13 years of age. Operation for repair of incisional hernia in lower abdomen. Two small faceted stones were felt in the gallbladder. During the following five and one-half years there were no symptoms suggestive of the presence of the stones. The patient disappeared upon recommendation of an operation for recurrence of the hernia.

Case 25—M W, colored, age 32 at time of operation, July 25, 1929 No typhoid Married and two pregnancies Hysterectomy for large uterine fibroid The gallbladder contained numerous medium-sized faceted stones Patient was followed for three and one-half years before being lost contact with and during this period was entirely free from symptoms and without need of restrictions in diet

Case 28—J B, colored, age 35 at time of operation, February 28, 1931 No typhoid Married and no pregnancies Hysterectomy for uterine fibroids A solitary stone found in the gallbladder, size of a marble Past history was irrelevant Thirteen years before there had been a gynecologic operation, the gallbladder presumably was not investigated Patient was followed for over a year, gaining in weight but complaining of flatulence, possibly related to her gallbladder

Case 33—G H, colored, age 42 at time of operation, February 2, 1933 No typhoid Married and no pregnancies Hysterectomy for uterine fibroids The gallbladder was thickened and contained a large number of stones There had been acute attacks of lower abdominal pain thought to be due to intestinal adhesions, which were found to be extensive at operation Fourteen years previously the patient had been operated upon for adnexal disease, the gallbladder apparently was not explored Patient was free of all symptoms when last seen, ten weeks after the discovery of the stones

Case 41—L E, colored, age 40 at time of operation, July 18, 1935 No typhoid Married and two pregnancies Hysterectomy for uterine fibroids A small round stone felt in the gallbladder, with probable additional smaller stones When last seen, nearly four years after operation, there had been no symptoms that might be attributed to the gallbladder during this period

Twelve cases found to have gallstones have continued under observation Six of these have had one or more attacks of biliary disease or are having symptoms at the present time, this during periods of observations ranging from 4 to 15 years Without regard to occurrences preceding the discovery of the stones, these cases seem properly to belong to the quiescent gallstone group

The six remaining cases are believed to have had no symptoms during periods of observation of 20, 15, 13, 9, 3, and 3 and one-half years Four of these have definitely had or cannot be said not to have had, symptoms prior to the discovery of the stones, and even though believed to have been symptom-free since, cannot be rated as cases of symptomless stones but are added to the quiescent gallstone group

Two of these 12 cases can be said to have had no symptoms before the discovery of the stones with considerable assurance They may be accepted as cases of symptomless gallstones, if such exist One of these was operated upon at the age of 38 and followed for 15 years, and one at the age of 49 and followed for nine years

Case 1—A H, age 30 at time of operation, July 5, 1918 No typhoid Married and five pregnancies Ventrosuspension for posterior displacement of the uterus A small number of faceted stones were felt in the gallbladder While this patient was of a thin and nervous type and had innumerable complaints, none of which could be assembled to form a picture of any one thing, it has been impossible to ascertain that during a period of over 20 years there have been symptoms that could be definitely attributed to the gallbladder

Case 6—S W, age 43 at time of operation, March 24, 1923 No typhoid Married and three pregnancies Operation for excision of ovarian cyst Gallbladder felt to

contain two medium-sized faceted stones. It was learned after operation that four years previously and three days after the birth of her last child, there had been a definite gallbladder attack, with jaundice. There have been two attacks without jaundice at intervals of five and ten years since the discovery of the stones. There has been no attack during the past three years.

Case 16—A W, age 38 at time of operation, August 18, 1926. No typhoid. Married and two pregnancies. Salpingectomy for ruptured ectopic. Gallbladder found to contain a stone the size of a marble, with several smaller stones. Owing to a misunderstanding with the family physician the patient was not informed as to the discovery of the stones for 15 years. When finally told of their presence, she stated that she was then and always had been in perfect health, asked as to the location of the gallbladder and what would be the characteristic symptoms should these appear.

Case 17—A M, age 45 at time of operation, March 3, 1927. No typhoid. Single. Hysterectomy for uterine fibroids. Gallbladder contained six or more very small stones. Patient was free from symptoms for nine years, then for one year was annoyed by gas and bloating and occasional crampy pains across upper abdomen. There has been no recurrence of these symptoms for the past five years.

Case 23—C H, age 52 at time of operation, April 27, 1929. No typhoid. Married and three pregnancies. Operation, salpingectomy with ventrosuspension. The gallbladder was felt to contain a small, solitary nonfaceted stone. The patient was seen a year after operation and then disappeared for twelve and a half years, returning thirteen and a half years after the discovery of the stone because of a breast tumor. She had had no symptoms that would indicate a disturbance caused by her gallstones.

Case 34—M M, age 49 at time of operation, April 4, 1933. No typhoid. Married and two pregnancies. Hysterectomy for uterine fibroids. Gallbladder contained a round stone and a number of smaller stones. Patient had had no symptoms referable to the gallbladder prior to operation, and has been entirely free from all such symptoms for more than nine years since.

Case 35—A W, age 35 at time of operation, October 3, 1933. Married and one pregnancy. No typhoid. Ventrosuspension. Gallbladder was felt to contain a considerable number of small stones. Eighteen months after operation patient developed digestive symptoms, chiefly gas and fat intolerance, regularly brought on by indiscretions of diet. These symptoms have persisted in variable degree for ten years, to date.

Case 37—I C, age 28 at time of operation, May 24, 1935. No typhoid. Married and three pregnancies. Gallbladder found to contain a round stone the size of a marble, with additional smaller stones. Three years after operation patient gradually developed digestive symptoms, with fat intolerance, which persisted for more than two years. The past year has been entirely symptom-free.

Case 43—M P, age 36 at time of operation, April 8, 1936. Married and two pregnancies. Ventrosuspension for posterior displacement of uterus. A very small and apparently solitary stone felt in the gallbladder. Six months following operation patient had a definite attack of biliary colic followed by two other attacks during the succeeding 12 months. There have been no recurrences during the past four years.

Case 48—M H, age 48 at time of operation, January 19, 1938. No typhoid. Married and one pregnancy. Gastro-enterostomy for pyloric obstruction. Symptoms had been typical of the gastric condition present. A faceted stone, apparently solitary, was felt in the gallbladder. Operation relieved all symptoms, the gallstone apparently having played no part in them. The patient has been in excellent health for three years, having gained in weight and general condition and remained free of all complaints.

Case 49—G D, age 48 at time of operation, February 18, 1938. No typhoid. Married and no pregnancies. Hysterectomy for uterine fibroids. Gallbladder found to contain one faceted stone one-half inch in diameter and numerous other small stones. The patient when informed of the presence of the stones stated that she had had indigestion for years. Fourteen months after operation fat intolerance developed, with

SYMPTOMLESS GALLSTONES

tendency to nausea and inability to manage full meals. These symptoms persisted for two years, and were followed by a year of greatly improved general health. When last reporting patient stated that she had not been so well in the past five years.

Case 50—L K, age 49 at time of operation, April 9, 1938. No typhoid. Married, three pregnancies. Hysterectomy for uterine fibroids. There were several small faceted stones in the gallbladder. Operation was delayed for some months because of attacks of epigastric pain, suspected of being of cardiac origin. This was not substantiated nor has it been since operation which was followed by complete relief of symptoms. There have been three and a half years without symptoms which are now believed to have been due to the gallstones.

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PREOPERATIVE MEASURES USED IN WAR SURGERY IN CHINA WITH SPECIAL REFERENCE TO THE DELIMITING TOURNIQUET*

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IT IS OUR PURPOSE to outline some of the preoperative measures which we found useful in taking care of casualties in connection with our experiences in the early part of the Sino-Japanese War (January, 1938, to January, 1941) These casualties were treated in four different North China mission hospitals on both sides of the fighting lines They were seen on the average of two or three days after wounding, but this varied considerably Some were seen immediately Unfortunately, our records have been lost to the enemy and hence are unavailable In general, we found that preoperative preparation of the patient was just as important as in civilian surgery, if not more so The form it took, however, differed according to the time that had elapsed after injury and the circumstances under which we worked

Shock —We were, unfortunately, not in a position to use the best methods in treating shock, for blood and plasma were not available except as donated by our own overworked staff In consequence of this, only the most exsanguinated could have transfusion If we had it to do over again, we would certainly press propaganda to the point where stored blood or plasma would be available in sufficient quantity, at least while we were working in Free China At any rate we did not encounter any deaths from injection of too much plasma (or too much of the contained sodium citrate), such as has been reported recently by Drummond¹ and Ivy, and his collaborators² We did give morphine subcutaneously, and saline and glucose intravenously as indicated, but we saw lives lost both in the initial shock following war trauma and postoperatively through lack of suitable intravascular fluid such as blood or plasma

Exhaustion —In the autumn of 1938, 33 Chinese stretcher casualties were landed on us all at once Because of lack of space in our reception rooms for so great a number of stretcher cases, they were seen in a preliminary way as they were lined up on the tennis court As we went from stretcher to stretcher, a composite picture was seen of utter exhaustion, malnourishment and fever They had been wounded in fighting the Japanese about 140 miles away and had been carried westward for eight days by litter-bearers over rugged mountain passes to reach our hospital Very few inns had been encountered along the way and the food and lodging which had been obtained was only of the coarsest variety There had been no immobilization of wounded parts and no dressings en route Their wounds were almost all

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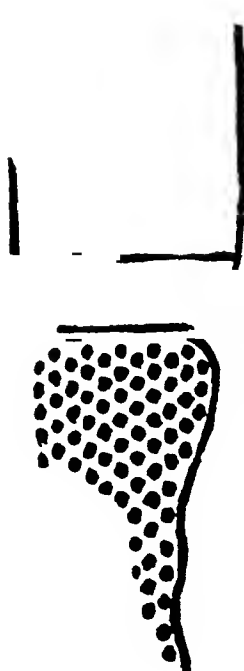


FIG 1—Single transverse line Level of proposed amputation (upper thigh)
Double transverse line Level of application of the delimiting tourniquet
Stippled area Area of gangrene induced by tourniquet
Black-shaded area Original area of gangrene and infection

badly infected and many were infested with maggots (indicating an extreme degree of contamination, no matter what may be said for the therapeutic value of the maggots!)

In a few of these cases we yielded to the temptation of operating right away and the results were decidedly disappointing, even with amputations for cutting away severely infected and gangrenous parts. Exhaustion and malnutrition had prepared them for the worst postoperative shock and stormy convalescence.

The rest of our 33 casualties, we kept in the ward for a week or more before undertaking the indicated operations. It was remarkable to see the preoperative improvement that came over them with a comfortable bed, congenial surroundings, immobilization of the wounded part by the simplest means, *e g*, a Thomas splint with adhesive traction supplemented in many instances with sulfanilamide by mouth, vitamins and good nourishing food. Practically all of these patients did very well on the operating table and thereafter. Thus, we learned that it is far more necessary to give rest and nourishment to such casualties than to undertake a spectacular and hurried operation. We later discovered that Keen³ had stressed this matter in his book on war surgery in the following statement:

"The wounded will often have suffered from loss of blood, loss of sleep, insufficient food, and exposure to cold, and if to these are added severe pain and the exhaustion due to an unavoidable jolting transportation, they will be on the verge of collapse. The first needs of such a man are rest, warmth and food. These restoratives may easily be required before any treatment (save for hemorrhage) should be attempted. 'The more experienced the surgeon, the less is he likely to hurry on a severe primary amputation.' Threatened gas gangrene or rapidly spreading sepsis may force his hand. Much discretion, therefore, must be allowed the surgeon."

Malnutrition—A great deal of inanition was seen among troops who, at best, were getting along on inadequate diets. Particularly was this true of the Chinese Communist Troops who practiced extreme Marxism, with its share-alike principles applied equally to civilians and military personnel, resulting disastrously in view of prevalent conditions bordering on famine. When these men became wounded, the problem seemed to be primarily one of hypoproteinemia and avitaminosis. Feeding them good nourishing food, rich in protein,⁴ and, in the more extreme cases, the administration of ascorbic

acid parenterally,⁵ seemed to play a big rôle in preoperative preparation and recovery

Infection—In many instances infection was inevitable in our war wounds, particularly in those which were seen late. We started using sulfanilamide tablets in January, 1938, when we received our first consignment of 3000 tablets. Sulfanilamide and small quantities of sulfapyridine were the only sulfonamides obtainable during the period under consideration, *viz* up to January, 1941. Sulfonamide powder, moreover, was not used locally because it had not become available in sufficient quantity. As a preoperative measure, saturation of the body tissues with sulfanilamide was usually accomplished by the administration of the drug orally (0.67 to 1.0 Gm every four hours), or, when speed was required by reason of coma or severity of infection, intravenously (500 cc of one-half per cent sulfanilamide in physiologic saline, followed by 200 cc every four to six hours), for at least 24 hours before operation. In our experience this decidedly cut down the amount of postoperative reaction.

Intercurrent Disease—Another thing that we encountered frequently was the casualty who had been holding the balance of power against latent disease, such as malaria. In the face of trauma and exhaustion, latent malaria tended to develop into clinical malaria, as demonstrated on frequent occasions by blood smear. Accordingly, when the temperature rose in our casualty cases, quinine was often just as likely to be needed as a sulfonamide. We frequently had to give both at once, as a matter of fact. It is particularly precarious to have a malarial chill superimposed upon postoperative shock.

Toxemia—In some cases seen several days after injury, the insult of toxemia was added to that of malnutrition and infection. Our experience with the use of what we might call, for want of a better term, the delimiting tourniquet,^{6, 7} would lead us to say that we believe that there is a very definite field for the use of the tight gum rubber tubing tourniquet to prevent absorption of toxic products from a severely septic and/or gangrenous extremity which will later require amputation. Gangrene and infection elaborate toxins by reason of tissue disintegration and bacterial growth. The resulting toxemia produces disturbed body metabolism. Should toxemia become severe enough, a comatose stage is reached which, if the toxemia continues unabated, eventually becomes irreversible and fatal. It is at the comatose stage that we have seen dramatic restoration of normal metabolism by the simple expedient of applying a tight tourniquet well above the affected area with a view to later amputation at this level or higher. The application of the delimiting tourniquet is promptly available in warfare in many places where freezing of the affected extremity, the beneficial effects of which have been demonstrated by Allen⁸ and McElvenny,⁹ is not.

The Rationale of the Delimiting Tourniquet—There appear to be two principal indications for the delimiting tourniquet. In the first place there is sometimes the need of preoperative improvement before subjecting the patient to amputation, and, secondly, there is the inevitable delay in getting the

severely toxemic casualty, who may have been lying out on the battlefield for two or three days, to a hospital. The tourniquet is applied distal to the anticipated level of amputation but sufficiently proximal to the diseased part that it is well above any area of infection. We would like to stress this particular point, for the application of the delimiting tourniquet to any part of the limb where there may be deep infection helps to further confine the products of inflammation.

In view of the fact that a previously reported case of our use of the delimiting tourniquet for gunshot wound is rather inaccessible at present, having been published in China shortly before America entered the war,⁶ it might not be amiss for us to give a brief summary of it, since it so well illustrates the usefulness of this procedure.

ILLUSTRATIVE CASE IMPROVED BY THE DELIMITING TOURNIQUET

Case Report—A Chinese official, age 26, was admitted to our hospital with a history of a gunshot wound in the posterior aspect of the lower third of the right thigh four days previously. On the day of injury and the following day, an orange-colored Chinese corrosive powder had been introduced into the tract of the missile. Previous experience had taught us that this corrosive powder continues to exert a necrosing action similar to phenol over a matter of many days. The next day the skin about the wound had turned black in color. On admission, the posterior aspect of the lower third of the right thigh was found to be gangrenous and an extensive slough was cut away without pain, followed by the outpouring of a serosanguineous fluid mixed with globules of fat. An area in the upper part of the calf of the right leg appeared to be threatened with gangrene, and the dorsalis pedis artery was not palpable on that side. Gangrene set in subsequently and gradually spread to include the entire right leg below the knee.

Eight days after admission, the gangrenous limb had so affected the patient's condition that he became unconscious. The following note was written on his chart that day: "Condition is so poor this morning that, while full consent for amputation has at last been obtained, it seems worthless. A tourniquet is being applied to keep poisons from going back to the heart as a preferable alternative." The tourniquet was applied tightly around the upper thigh.

Up to the day of the application of the tourniquet, the temperature of the patient had become steadily higher, having ranged between 103° and 104.8° F for the four days preceding. On the morning of the following day, 24 hours after the application of the tourniquet, the temperature had fallen to 100.4° F. The patient was again conscious, with some appetite for food, and was demanding amputation, but as the relatives were not unanimous at that time, it was not undertaken. Twenty-eight hours after the application of the tourniquet, the temperature again rose, this time to 105.4° F. His condition became steadily worse until death ensued 53 hours after the application of the tourniquet. Our feeling was that this patient had so improved that he would have stood amputation better 24 hours after the application of the tourniquet than before.

Precautions in the Use of the Delimiting Tourniquet—It is of course necessary to see that the delimiting tourniquet is not released until amputation is performed. We are aware that this, at first sight, seems to contravene some of our present U. S. Army directives as regards the frequent loosening of the tourniquet. It must be remembered, however, that these directives refer

to the control of hemorrhage. We feel that the use of the tourniquet for controlling toxemia belongs in a very different category. Our suggestion is that when the delimiting tourniquet is applied, it should be extensively covered with adhesive tape which is appropriately labelled, indicating that it is not to be removed.

Subsequent experience with two other cases in addition to the one reported above makes us inclined to recommend reapplication of the delimiting tourniquet every 24 hours at a slightly higher level each time, until amputation is performed, so as to avoid contact of normal tissue with toxic fluids produced by pressure necrosis at the point of application of the tourniquet. Our reason for suggesting 24 hours as the time limit is that we noted a sharp rise of temperature soon after the lapse of 24 hours in those cases where we did not reapply the tourniquet at a higher level. On the other hand, Maxeiner⁷ apparently did not resort to reapplication at a higher level and his results were seemingly as good. Whether more rigid attention to tightening the tourniquet *in situ* would have accomplished the same thing in our cases, we do not know.

In reapplying the tourniquet, the old tourniquet is left in place until another tourniquet has been applied proximal to it. It is applied as tightly as possible. At the end of several hours it usually produces a very deep indentation in the soft tissues, often with obvious local liquefaction necrosis.

Ordinarily, if the delimiting tourniquet is applied when the patient is in coma, there is no pain nor discomfort even after full consciousness returns. If the tourniquet is applied (or reapplied) when the patient is not comatose, there is a very painful reaction for which morphine should be administered beforehand. After the first hour or two there is no pain, since the tourniquet produces anesthesia by that time. We do not feel that the patient need necessarily have advanced to the comatose stage in his toxemia before the delimiting tourniquet is first used. Nevertheless, his condition must obviously be severe enough to require amputation before resorting to this procedure.

Conservative Treatment for Gas Gangrene—Gas gangrene gave disappointing results in our earlier cases where we did immediate amputation. The use of conservative measures with delayed amputation or no amputation at all, seemed to give the best results. Sulfanilamide was administered, intravenously the first day in our serious cases, after which it was given orally. This seems justifiable, largely on the basis that the sulfonamide counteracts the symbiosis of streptococci with gas gangrene bacilli.¹⁰ In our four cases seen in 1940, amputation was deferred and we were able to carry them through to a successful issue despite the fact that we did not have antitoxic serum for gas gangrene available. They received no local treatment aside from establishment of drainage in the simplest manner, changes of dressings and immobilization, as indicated. Thus, amputation was postponed for several weeks even though they were very toxic. In half the cases amputation did not prove necessary whereas in the other half we were able to

perform a more conservative amputation than would have been otherwise possible

The Delimiting Tourniquet for Gas Gangrene—On further reflection, we are inclined to say that the delimiting tourniquet might find a useful field in the treatment of gas gangrene in cases where eventual amputation will be required, although we did not actually use it in our cases. Our reason for this suggestion is that these patients are extremely toxic. Reimers,¹¹ furthermore, reports the successful use of a tourniquet under somewhat similar circumstances.

"In cases in which gas gangrene has already set in, and serious damage from injuries requiring amputation is present, the author recommends an immediate tourniquet bandage at the point of the intended amputation. He has never seen gas gangrene spread beyond the point of the tie-off."

Maxeiner⁷ also expresses a similar viewpoint by implication when, in the discussion of one of his cases, he says

"Gas bacillus infection certainly would not have occurred if, in our eagerness to conserve all possible tissue, we had not placed our tourniquet too low."

COMMENT—These procedures for improving the conditions of our casualties before operation doubtless differ somewhat from those which are used on other battle fronts. Certainly intravenous plasma and blood are being utilized elsewhere more than we used them. In general, however, the problems of shock, exhaustion, malnutrition, infection, intercurrent disease, toxemia and gas gangrene remain the same, although their relative importance may vary. No substitute can be found for good surgical judgment in their solution. The delimiting tourniquet should play a life-saving rôle in some instances, but its implication, namely, inevitable amputation, must be constantly borne in mind.

SUMMARY

Our experiences with methods for improving the condition of our casualties in China have been recounted, especially in regard to shock, exhaustion, malnutrition, infection, intercurrent disease, toxemia and gas gangrene. The rôle of intravenous fluids, rest, protein-rich diet, ascorbic acid, sulfonamides, specific treatment for intercurrent disease, and the delimiting tourniquet, as preoperative measures, is outlined. In particular, the effects of the delimiting tourniquet are discussed and an illustrative case is presented.

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CYSTOMYOMA OF SEMINAL VESICLE*

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THE RARITY of this lesion warrants description and discussion of every case To our knowledge, no such observation has been reported in the Anglo-American literature

Case Report—Hosp No 152951 M L, white, male, age 66, was admitted to the Beth Israel Hospital, May 6, 1943, because of a palpable mass in his left lower abdominal quadrant, which had been noticed two months previously It occasioned him no pain or discomfort and he was not aware of its presence The mass had not increased in size since it was discovered There had been no abnormal gastro-intestinal symptoms Appetite had been good, bowels regular, no blood had been noticed in the stool There had been no weight loss, no dysuria, nocturia, hematuria or urgency Neither had there been any symptoms of loss of cardiac reserve, the patient having carried on his usual occupation without interruption

Physical Examination The patient was thin, lungs clear to auscultation and percussion, pulse 80, regular sinus rhythm, no murmurs heard, blood pressure 138/80 The abdomen was scaphoid, soft, not distended The liver edge was palpable 5 cm below the costal margin, it was sharp and smooth The spleen was not palpable In the left lower quadrant there was an irregularly, round, hard nodular mass, about 8 x 8 cm in diameter It was movable but not freely so, and not tender Rectal examination revealed no intrinsic lesion Bimanual palpation with one finger in the rectum and the other hand on the abdomen demonstrated that the mass extended into the pelvis, almost completely filling it It was fixed and immovable in the pelvis, but pressure by the abdominal hand was transmitted through the mass to the rectal finger The prostate was in normal position and of normal consistency

Barium enema showed no intrinsic colonic lesion, but the rectum and sigmoid were pushed to the right by the mass filling the pelvis

Laboratory Data Red blood cells 4,600,000, hemoglobin 88 per cent, white blood cells 6,200, with 69 per cent polymorphonuclear leukocytes Urine Specific gravity, 1.012, glucose negative, albumen faint trace, white blood cells 18-20 per H P F, numerous urates

Clinical Diagnosis The original diagnosis rested between carcinoma of the rectum, with pelvic involvement, and retroperitoneal tumor, possibly fibrosarcoma or neurofibroma

Operative Pathology May 11, 1943 (Dr Standard) The sigmoid was pushed to the right by a retroperitoneal, lobulated, hard mass which filled the pelvis and the entire hollow of the sacrum, pushing the bladder anteriorly Portions of the tumor were cystic and these cysts contained dark, thick, chocolate-brown fluid One such cyst was located deep in the hollow of the sacrum close to the area of the seminal vesicles, and the left vas deferens seemed to emerge from it The entire tumor was well-encapsulated and could be enucleated along its lines of cleavage The mass was roughly 15 x 13 cm in diameter (Fig 1)

Operative Technique Left midline muscle-splitting incision Rectus fascia was split and the rectus muscle displaced laterally Peritoneum entered Small intestine packed

* Submitted for publication October 15, 1943

off under the upper angle of the wound. The posterior peritoneum along the left lateral surface of the tumor was incised and the tumor enucleated from its retroperitoneal bed. There was some spillage of dark brown fluid during the enucleation. There was a sharp line of cleavage between the major portion of the solid tumor and the cystic portion (3 x 4 cm) which lay deep in the pelvis and from which the left vas deferens arose. The vas was ligated and cut from the cyst. (The other vas, which was found in the specimen, was not recognized during operation.) The bladder was identified anteriorly and a catheter inserted. Clear urine was evacuated when the procedure was completed. Posterior peritoneum resutured over bed of tumor and abdomen closed in layers.

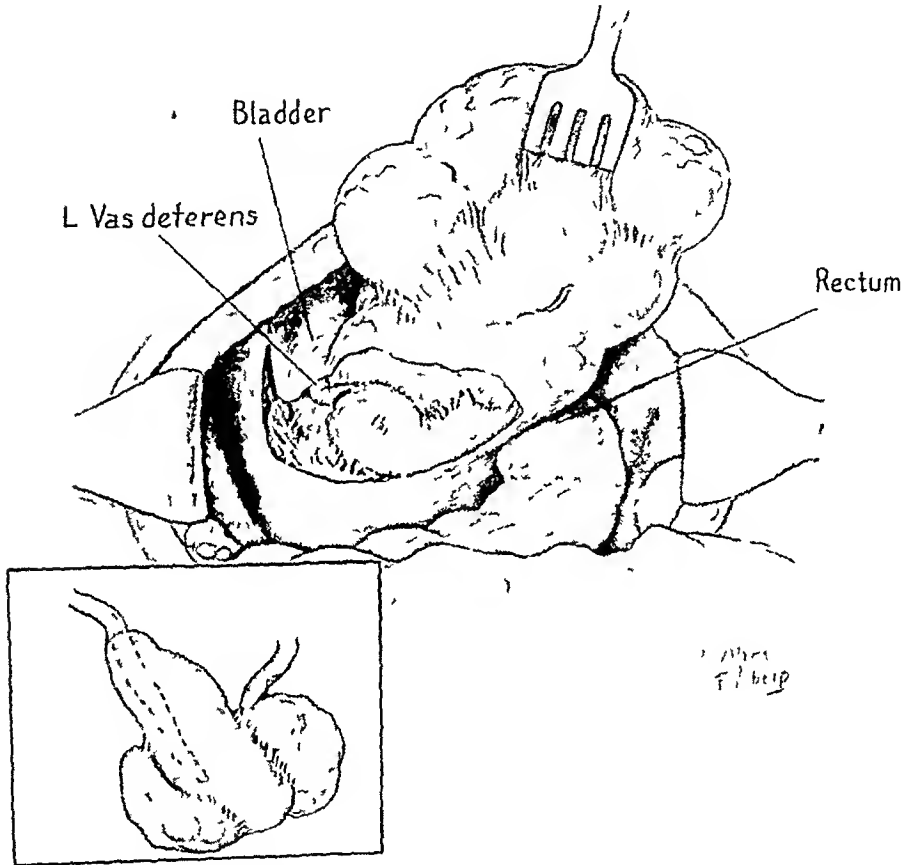


FIG 1—View of operative field (reconstructed), looking into the pelvis from above. Through a window in the posterior peritoneum one sees the left vas deferens and the adjacent cyst. The recto sigmoid has been pushed towards the right by the tumor. The retractor has pulled the myomatous mass out of the abdominal cavity.

(Insert)—The dotted line indicates the course of the ductus deferens within the cyst wall.

Postoperative Course Uneventful. Wound healed *per primam*. Patient discharged 13 days after operation.

Follow-up Three weeks after operation the patient reported noting "blood in his urine." The urine was brown, microscopically, it showed no red cells. The color of the urine was due to the same brownish, thick material which had been originally evacuated from the tumor. Only on two occasions, a few days apart, did the patient notice this discoloration of the urine.

Today, more than five months after operation, the patient is in perfect health.

Pathologic Examination—Gross No 43184. The specimen was irregularly lobulated and firm. It consisted essentially of one somewhat kidney-shaped piece, 14 x 11 x 8

CYSTOMYOMA OF SEMINAL VESICLE

cm, which was connected to another irregularly ovoid piece, 8.5 x 6 x 6 cm, by means of a pedicle-like structure. The specimen was surrounded by a hyperemic capsule in which many larger and smaller blood vessels were seen. Hyperemic membranous flaps were loosely attached to the outside. The one surface of the larger ovoid piece

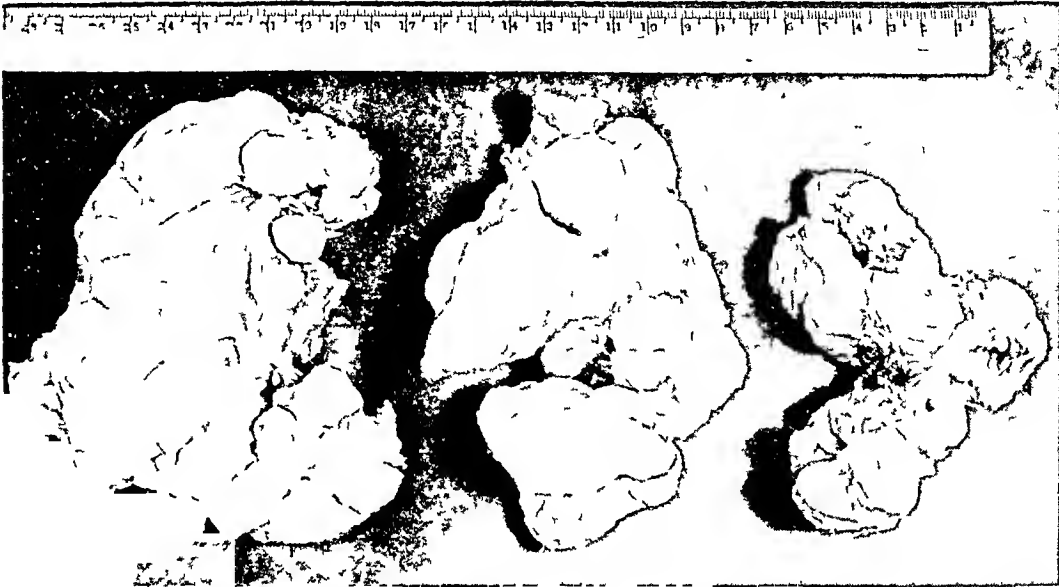


FIG 2—Gross specimen after fixation. Note the characteristic round myomatous nodules. The whitish areas in the middle specimen correspond to recently made cut surfaces. The cavity is visible in the largest piece.

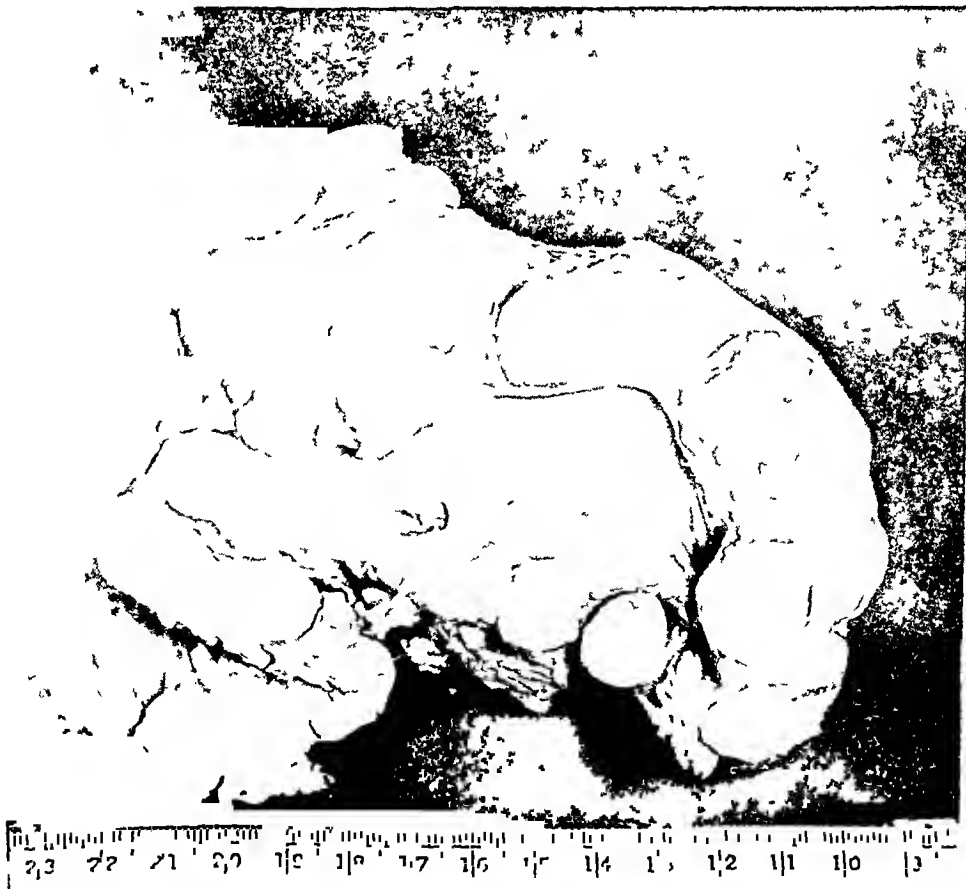


FIG 3—Close up of largest piece. The high lights indicate the smooth lining in the cavity.

was flat, the other one irregularly convex. Both pieces were subdivided by grooves between which irregularly ovoid portions of different sizes protruded. A long section through the larger piece clearly showed many, more or less completely separated, nodules. The cut-surfaces could best be described as being very similar to those of myoma uteri.

Near the convex surface of the large piece a cavity was situated. Its volume was about one-fourth of the whole piece. It was crescent-shaped, it had a distinct smooth lining which was sharply demarcated from the surrounding tissue. The cavity had prolongations whose outlines corresponded to the contours of the whole piece. A transverse incision into the smaller piece opened a similar smaller cavity. Both cavities contained rather thin, dark reddish-brown fluid (Figs 2 and 3).

A flat, soft, hollow specimen, $9 \times 4 \times$ about 1 cm, was received separately. It had torn prolongations and two ovoid thickenings. From an opening at one end dark, brownish fluid exuded. The lining of the cavity was smooth, partly pale, partly deep red. One of the prolongations contained a continuation of the cavity, about 1.2 cm wide. The other protrusion was a thin, firm, cylindrical structure with very narrow lumen and firm elastic, obviously muscular, wall. Both looked like vas deferens. The outer aspect of the ovoid thickenings was suggestive of seminal vesicle, the cut-surfaces were characteristic (see insert to Fig 1). The one seminal vesicle-like structure measured $3 \times 1.5 \times 1$ cm, the other one $3.5 \times 2 \times 1.3$ cm. They were separated by a piece of cyst wall, about 1 cm wide. The cylindrical structures which entered this specimen really were the vasa deferentia. They were normal in thickness and slightly tortuous. They entered the wall of the cystic structure at an acute angle and ran mostly in the wall, with their lumina very near the surface. The average width of the lumen was 2.5 mm. About one centimeter from the one pole of one seminal vesicle the lumen was somewhat widened.



FIG 4—Characteristic structure of mucosa of seminal vesicle. The lining of the cyst appears in the upper portion of the specimen as a thin, dark contour.

The probing of the ducts was done after fixation of the specimen. Through the one the probe passed easily, not through the other. There was, however, no reason to assume that the other duct did not communicate with the lumen of the cyst.

Microscopically, the picture of the solid tumor was that of fibromyoma. As is usual in such tumors, the ratio between muscle and connective tissue varied, and so did edema and inflammation, the latter not being severe anywhere. Elastic fibers were few except for the subepithelial layers. These layers ran parallel to the surface of the cavity and, thus, were more regularly arranged than the layers which formed the myoma proper. The subepithelial layers contained small amounts of light brown pigment. The cavity in the myoma was lined with a single layer of cylindrical cells. There were no glands. The cells did not contain mucin. Directly under the epithelium some large, obviously phagocytic, cells were situated.

CYSTOMYOMA OF SEMINAL VESICLE

In sections from different portions of the cystic specimen (Figs 4 and 5) the microscopic pictures were those of seminal vesicle, ampulla or vas. The muscular walls of these structures were continuous. There was some pigment in epithelium and in muscle. Subepithelial phagocytic cells were present. There were a few calcifications in the mucosa. Sperm heads were found in the lumen. The characteristic subepithelial elastic structures were conspicuous.

Only four reports of such cases could be found, none in the English or American literature.

E. Emmerich, in 1910, reported the first one under the title "Enormous Cyst of Vas Deferens." The tumor was found accidentally during the autopsy of a 74-year-old man who had died of leukemia. No urologic symptoms had existed and no pelvic pain. Both seminal vesicles were normal, as were testicle and epididymis on both sides, the prostate gave the picture of ordinary

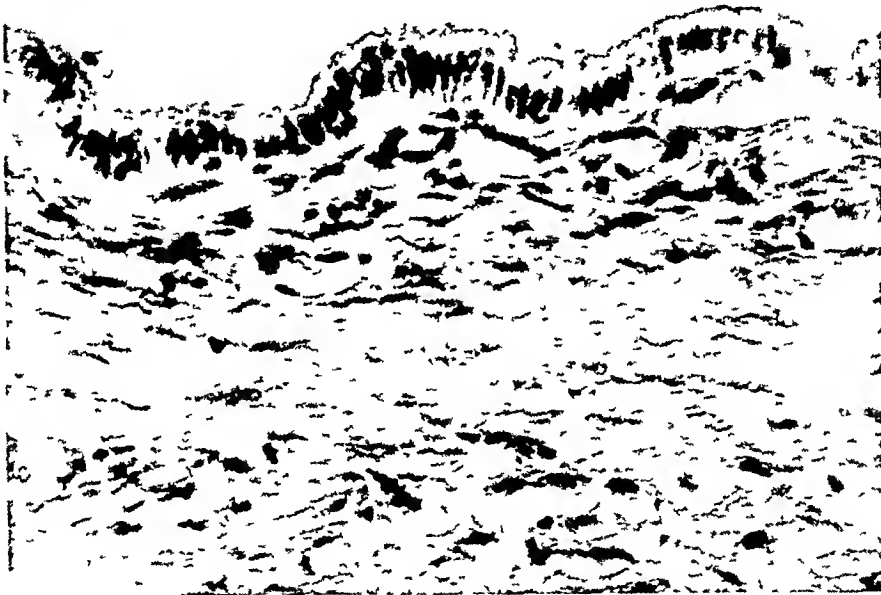


FIG 5—The cavity is lined with a single layer of regular high cylindrical epithelium

hypertrophy. Right kidney and ureter were absent, there was no trace of a right ureteral opening in the bladder. The tumor (Fig 6) arose from the left vas deferens, between ampulla and ejaculatory duct. It consisted of a round, firm, smooth, fist-sized mass which protruded from the small pelvis to the right of the midline. This mass was attached to the left ampulla towards the midline by means of a thick-walled hollow stalk, 6 cm long. The lumen of the stalk communicated with the lumen of the ampulla and with the epithelium-lined cavity in the fist-sized mass. The wall of this cavity was only 2 mm thick, that of the cylindrical portion was thicker, both consisted essentially of smooth muscle fibers. The epithelium was cylindrical or cuboidal. No spermatozoa were found.

Emmerich considered his case a cyst of the vas deferens, on the basis of a congenital malformation.

In 1912, Voelcker published a case of "Myoma of the Capsule of the

Seminal Vesicle"—this is the only case with clinical symptoms. Voelcker's patient was 56 years old, for more than 15 years he had suffered from pain in the perineum, he had consulted numerous surgeons, had been proctoscoped frequently, had been subjected to various procedures with no avail, and had, finally, become a morphine addict. On rectal examination a nontender swelling could be felt above the prostate. On bimanual palpation, in Trendelenburg position, under general anesthesia, it appeared as a movable, firm, smooth, spherical mass in the region of the seminal vesicle. The posterior wall of the bladder was pushed forward by this mass.



FIG 6—Emmerich's case (Zentralbl f allg Path u path Anat, 21, 673, 1910). View from behind. The urinary bladder occupies the left half of the picture, the left ureter is normal. (The right ureter and kidney were absent in this patient). From the ampulla of the left vas deferens the tumor arises. Both seminal vesicles and the right vas deferens are normal.

Voelcker exposed the tumor by a paracoccygeal approach, severing part of the gluteus muscle, the tuberosacral ligament and the levator ani. After incision of the visceral pelvic fascia the rectum was pushed towards the midline and the smooth surface of the tumor came into view. Most of the tumor was shelled out, a small portion which was adherent to the bladder had to be left behind. The patient was discharged after three weeks. When seen six months later he was in perfect health.

The specimen was a fist-sized tumor which, grossly and microscopically, looked like an ordinary myoma. It contained a small cavity without epithelial

CYSTOMYOMA OF SEMINAL VESICLE

lining Voelcker explained the tumor as a myoma originating from remnants of the mullerian duct. No illustration is given.

In the same year (1912) Ceelen described a huge "Fibromyoma of Seminal Vesicle." It was found, protruding retroperitoneally from the small pelvis, at the autopsy of a 67-year-old man who had died of cirrhosis of the liver. No mention is made of clinical symptoms. The tumor had the size of a baby's head, rectum and lower sigmoid were pressed against the sacrum. The thick-walled urinary bladder was pushed to the left and pressed against the anterior aspect of the tumor. The prostatic portion of the urethra was drawn out, the prostate, which was not hypertrophic, was elongated, with its posterior surface firmly pressed against the tumor. Both ureters were



FIG 7—Voelcker (Chirurgie der Samenblasen, 1912)
Remnants of midportion of right mullerian duct. The genital tract is filled with collargol. Metal probes are inserted into the ureters.

compressed, their upper portions were as thick as a pencil. The right kidney was normal, the left kidney pelvis was distended, and the kidney substance only 1 cm thick. The bladder mucosa was trabeculated, the ureteral openings could be probed easily. The colliculus was distinct. The right ejaculatory duct was missing, there were two lumina on the left side. The left seminal vesicle and vas deferens were normal. The right seminal vesicle, which appeared much smaller, was continuous with the tumor, the right vas was stretched over the tumor. The center of the mass was formed by a cavity with shaggy, partly necrotic wall, it contained dull grayish-red fluid with blood clots. The outer solid portion was 3-4 cm thick yellowish-gray and

grayish-white The histologic picture was that of fibromyoma, some of the muscle cells contained pigment similar to that found normally in the muscle of the seminal vesicle No illustration is given, and nothing is mentioned about histogenesis

After a long interval (1930) a fourth case was reported, by Panà, under the title "Leiomyoma of Seminal Vesicle and Ductus Deferens, on the Basis of Malformation" This tumor also was found at autopsy The 59-year-old man had suffered from tabes, syphilitic aortitis and chronic kidney disease A pear-shaped retroperitoneal mass (8 x 7 x 5 cm, weighing 110 Gm) was attached to the left seminal vesicle by means of a hollow pedicle, 9 cm long, 1.5 cm thick The lumen of the pedicle was continuous with that of the seminal vesicle and with an epithelium-lined cavity in the pear-shaped mass This cavity was lined with cuboidal epithelium, there were neither glands nor pigment The gross and microscopic picture was that of myoma There was a moderate right hydronephrosis caused by compression of the ureter Panà interprets the pedicle as either left ampulla or hypoplastic left seminal vesicle He considers the possibility of a mullerian remnant with hypertrophy of muscle

Somewhat similar to these cases, but only as large as a cherry, was a cyst Luksch found at autopsy, in 1903, between the vasa deferentia of a 54-year-old man The wall consisted of smooth muscle, the cavity was lined with a single layer of epithelial cells Luksch considered it as mullerian

COMMENT—Large tumors in the female pelvis frequently are symptomless (myoma uteri, ovarian cystoma), because they may have grown slowly and need not interfere with important functions The situation is the same with these tumors of the seminal vesicle or ampulla, thus, the fact that most of these tumors have been found accidentally is not so astonishing

In Voelcker's case only, clinical symptoms (pelvic pain) were present They appeared in the fourth decade, 15 years before operation One may assume that the slowly growing myomatous tumor had then existed for some time previously The three other tumors reported in the literature were found at autopsy of old men (74, 67 and 59 years) There is no way of knowing at what time of life they may have formed or had attained their final size The same applies to our case, in which the detection of the tumor was hardly less accidental One might point out the fact that these tumors, while based on malformation, became manifest late in life, but it would be futile to speculate about the causes of this seeming discrepancy

These tumors resemble myoma uteri so closely that the idea of mullerian origin will present itself almost automatically Emmerich speaks only about congenital malformation, not mentioning mullerian origin specifically, there is hardly any doubt in our mind that Emmerich's tumor is mullerian, in spite of Schneider's attempt at tracing it to ureteral muscle

Voelcker, as mentioned, considered his tumor as a myoma originating from remnants of the mullerian duct In his monograph on the surgery of the seminal vesicles Voelcker shows a beautiful roentgenogram of a mullerian

remnant in a 58-year-old man (Fig 7) He feels that by filling specimens with contrast substance one might find more of these very rare malformations

Ceelen gives no opinion concerning the genesis of his "Fibromyoma of Seminal Vesicle"

Luksch mentions the mullerian nature of the cyst, and Voelcker agrees with him

Some of the smaller cysts of seminal vesicles (Schwarzwald) and some of the retrovesicular cysts, as mentioned by Priesel, are also explained as remnants of the midportion of the mullerian duct The remnant of the proximal portion of the mullerian duct, the hydatid of Morgagni, is an almost regular finding, the remnant of the distal portion, the utriculus, belongs to normal anatomy, but the midportion usually disappears early in embryonic life, without leaving traces Vestiges of it have been described (Priesel, Voelcker, Luksch) They are considered great rarities, and it is even more uncommon that they develop into a tumor, as in our case It remains unknown under what exceptional conditions this happens

There is no preference for the right or left side The right kidney and ureter were absent in Emmerich's case In Ceelen's case the right ejaculatory duct was missing, while two lumina were found on the left side Panà's case showed no further malformations, neither did Voelcker's, nor did ours (as far as this can be determined in the living patient)

The tumor in our patient obviously originated from the point where ampulla and seminal vesicle meet

SUMMARY

A large myomatous tumor, closely resembling uterine myoma, has been found attached to the ampulla or seminal vesicle of a 66-year-old man

Remnants of the midportion of the mullerian duct are the source of these tumors

Only four such cases have been reported, one of them in a living patient

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TERATOMA OF THE TESTICLE*

METASTASIS TO THE EPIGASTRIUM TREATED
BY BILATERAL ORCHIDECTOMY—RECOVERY

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BY ANIMAL EXPERIMENTS Huggins, and his coworkers, found that androgens stimulated prostatic secretions and that estrogens put an end to the flow of this substance. With stimulations by the androgens the epithelial cells of the prostate became hyperplastic and metaplastic. The hyperplasia was so marked as to resemble cancer. Following treatment with estrogens they promptly returned to normal. After further study and observation Huggins began to castrate men for metastatic cancers of the prostate, with brilliant results.

In June, 1942, Doctor McClelland before the American Urologic Association meeting in New York, in discussing one of the speaker's papers, reported a patient who had embryonal carcinoma of the testicle, with generalized metastases and after removal of the normal testicle the patient improved, with general disappearance of all the metastases, as evidenced by palpation and roentgenograms of the epigastrium and the lungs.

The patient was a Norwegian flier, age 26, who had embryonal carcinoma of the testicle. This testicle was removed in April, 1941. In September, 1941, roentgenograms showed metastases in the lungs, and in October, 1941, a palpable tumor mass appeared in the epigastrium. He was losing ground fast. Thinking that this might be a genital tract tumor influenced by testicular secretions, as in carcinoma of the prostate, and having Huggins' work in mind, it was decided to remove the other testicle. This was done. Two months later the epigastric mass could not be palpated, and three months after castration there was no roentgenologic evidence of metastases. The patient gradually improved, and when last seen in May, 1942, he was to resume his flying. No roentgenotherapy was given after the second operation, although he had three courses of high voltage roentgen-ray treatments prior to October, 1941.

Doctor McClelland reported another case who had teratoma with lung metastases. The patient did well after removal of the second testicle in February, 1942. However, the condition was too far advanced, and he received some roentgen-ray treatments. Death in this case occurred in July, 1942.

After hearing about these amazing and extraordinary results, I decided to employ bilateral orchidectomy upon a patient of mine whom I was called

*Read before the Philadelphia Academy of Surgery, November 1, 1943

to see in August 24, 1942, and who was admitted to the Jefferson Hospital August 27, 1942. It took a lot of courage for the patient to consent for the removal of the normal testicle. He consented with the full knowledge that he would lose the power for sexual intercourse. As to propagation, his wife had had a pelvic operation and could not have any children. The wife, being advised about the operation, and fully understanding the consequences, agreed to the operative procedure.

Case Report—J. L. B., white, male, age 50, complained chiefly of loss of weight of 53 pounds in six months, pain in the left testicle and the left groin, with radiation down the thigh, swelling of the left lower extremity, chills and night sweats.

Previous History—In 1916, while playing baseball a batted ball hit his testes, at which time he felt some sharp pain for a few minutes. He did not stop playing, and no trouble, such as swelling or discoloration of the scrotal sac, was noted. In 1938, while on a ship, the left testicle became swollen and painful. This condition lasted for about two months, and the only treatment which he received was local application of some ointment. He had had no other illness, and always enjoyed good health.

Present History—In December, 1941, he began to feel some discomfort in the left testicle and occasional pain in the groin. This gradually grew worse, and later he noticed some swelling and redness of the scrotum, and swelling of the left lower extremity. He also began to tire easily accompanied with pain in the back when walking. There was an appreciable loss of weight, from 186 to 133 pounds. He never vomited or spat blood, and no blood was noted in the stools. He had received no medical aid until first examined by me August 24, 1942.

Physical Examination—The patient was an emaciated and undernourished individual, with marked pallor and sallow complexion, who was very nervous, irritable, and toxic. Pulse 110, respirations 20, temperature 101° F. There was a nonpulsating visible mass in the epigastrium which did not move with respiration, the scrotal sac was large and swollen, and somewhat reddened, the left lower extremity was twice the size of the right one, and the venous circulation was more prominent on the left side as compared to the right.

There were no enlarged cervical or supraclavicular nodes. The mass in the abdomen occupied the whole epigastric region. It was about eight inches in diameter, well circumscribed, smooth, nonfluctuating, and its movability was limited. The inguinal nodes were palpable, but there was little variation on the two sides. The left testicle was not tender, however, it was two and one-half times the size of the right one, and was smooth and firm in consistency. The left lower extremity showed no tenderness on pressure and no pitting edema. Pulsation was present in the femoral arteries. Rectal examination was negative. *Provisional Clinical Diagnosis* Carcinoma of the testicle, with metastases.

On August 25, 1942, a roentgenogram showed a large tumor mass just to the left of the spine in the lower dorsal and upper lumbar region. There were several areas of calcification within the tumor. The psoas line was obliterated. A barium meal showed a normal esophagus, stomach, and duodenum. Roentgenograms of the chest showed no abnormality in the lungs or heart. None of the roentgenograms showed metastases to the bones of the spine, pelvis, hip joints, or the ribs. *Roentgenologic Diagnosis* Metastatic retroperitoneal mass.

Laboratory Data Blood Wassermann negative, urine negative, hemoglobin, 55 per cent, RBC 3,200,000, WBC 8,600, normal differential. The patient received a transfusion of 500 cc of blood.

Operation—September 11, 1942. Under local anesthesia a bilateral orchidectomy

was performed, at the same time resecting the spermatic cords as high as possible. The operative recovery was uneventful. After receiving two more blood transfusions, the patient was discharged from the hospital September 23, 1942.

Pathologic Examination—In the parenchyma of the left testicle there was a yellowish body, 2 cm in diameter, with a whorl-like formation. Histologically, the hematoxylin and eosin stained section showed a division of the tumor into a number of alveoli by the fibrous tissue. The cells were quite large, arranged in sheets, and had a clear cytoplasm with round and oval nuclei. There were many hyperchromatic nuclei and few mitoses. The tissue was vascular and showed extensive necrosis. The right testicle presented no pathologic changes. *Pathologic Diagnosis* Teratoma of left testicle.

Postoperative Course—The patient received roentgenotherapy over the epigastric mass and from the back over the vertebral column. Roentgenotherapy was employed mainly to reduce the size of the large tumor mass, as it interfered with the lymphatic and blood circulation by pressure on the vessels and probably blockage of the lumens with metastatic deposits. This mechanical obstruction produced the enormous increase in the size of the left lower extremity.

These treatments were given in fractionated doses from August 28 to September 18, for a total of 3,500 r units. They were stopped because the patient developed a marked leukopenia. The white blood cells decreased from 10,900 on August 28 to 3,300 on September 21. No roentgenotherapy has been employed since that time.

Subsequent Course—After the operation there was a steady improvement in patient's general physical condition. The tumor mass in the epigastrium gradually disappeared, and finally, by November 1, 1942, could not be palpated. The weight increase was remarkable, increasing from 133 to 148 pounds by October 30, 1942, 185 pounds by March 22, 1943, and 197 pounds by October 27, 1943. The swelling in the left lower extremity slowly subsided, and the elastic bandage which he used on the leg was discarded by February, 1943, when the measurements of both thighs had become the same. A recent blood examination showed RBC 4,200,000, WBC 6,500, hemoglobin 82 per cent. When seen October 27, 1943, the clinical examination was absolutely negative. There was no evidence of recurrence at the site of operation or any other place in the body.

One of the most significant examinations was the uranalysis by the Endocrine Laboratory. On September 3, 1942, the Friedman test was positive on two animals while the qualitative serum gonadotropins were 330 mouse units per 100 ml of blood, which is an enormous increase from normal and well within the range of pregnancy. The urine estrogens were within normal as were the 17 ketosteroids. On October 24, the Friedman test was negative, the quantitative serum gonadotropins were nondemonstrable, and the quantitative urine gonadotropins were 56 mouse units for 24 hours. The urine values were slightly high, and the serum values were within normal. About six months later, on February 23, 1943, the serum gonadotropins were 10 mu per 24 hours, both of which are within normal range. On October 13, 1943, the Friedman test was negative, and the urine gonadotropins were 20 mu for 24 hours, which is also within the normal range.

It is well known that an increase in the gonadotropins is indicative of hyperactivity in the chorionic tissue either in the primary focus or in the metastases. In this patient these tests are very important, because, so far, they show there is no functionally active chorionic tissue. I believe these kinds of hormone assays and tests are very essential in judging the progress of this type of pathology.

Besides the clinical and the hormone assays, follow-up roentgenologic study was made October 27, 1943. The report was that there is no roent-

TERATOMA OF TESTICLE

genographic evidence of metastases in the lungs, pleura, ribs, spine, or shoulder girdle. The heart was normal. There were no tumor masses in the abdomen and the kidneys showed normal outline. The psoas lines were normal and no metastases were found in the lumbar spine or the pelvis.

Another interesting observation was that the patient reported he had a penile erection, February 1, 1943, which lasted for one minute, and another on February 6 which lasted for a longer time. On March 19, the patient had an erection which lasted for five minutes, at which time he attempted sexual intercourse, but his wife was not responsive. Since that time he has often had slight erections which last only for a few minutes.

SUMMARY AND CONCLUSION

A report is made of a patient who had a teratoma of the left testicle, with a large metastatic retroperitoneal mass. He was treated by bilateral orchidectomy, which was supplemented by the use of roentgenotherapy to reduce the epigastric mass. Fourteen months after the operation the patient is enjoying the best of health. On physical examination October 27, 1943, including hormone assays and roentgenologic studies, he showed no evidences of tumor recurrence.

It is not known what relation there is between sex hormone and cancer, but apparently there is some carcinogenic agent which must have been influenced by the removal of the testes. I realize it is too early to draw any conclusions, however, this report is made with the hope that others might apply the same procedure and record their results. It will be very gratifying if their patients benefit as much as mine has up to the present time.

COMPOUND FRACTURE OF THE FINGERS

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A METHOD is herein described for the treatment of compound fractures of the fingers which has enabled the author to obtain better results, with reduced loss of working time and cost of treatment. The method is not original. It is one which Orr¹ and Trueta² have applied to compound fractures of the larger bones, adapted to the fingers.

Finger injuries probably outnumber injuries to other parts of the skeletal system. Since fingers are in a sense the tools of the laboring man, finger injuries result in a significant loss of industrial time.

Despite these facts, finger injuries have not received the serious consideration they merit. As late as 1941, Couch³ and Oldham⁴ published what appear to be fundamental principles for finger amputations. The fact that surgeons have not been familiar with these principles for years is an indication of their attitude toward all finger injuries.

With the present emphasis on industrial loss of time, all treatment of laboring persons must be considered from the point of view of loss of working time as well as end-results. Methods of treatment which were satisfactory in peace time may be inadequate in war time because they do not give a good result with the least loss of industrial time.

Costs of treatment are being studied carefully in the present effort to increase industrial efficiency. Poorly devised methods of treatment of finger injuries, loss of working time and poor functional results following finger injuries contribute significantly to the high cost of treatment.

METHOD OF TREATMENT

Compound fractures of the fingers were treated as emergencies to prevent infection. In only one case was shock sufficiently severe to require the administration of 500 cc of blood plasma.

The majority of the patients were taken to the operating room. The wisdom of this procedure was soon apparent. It was obvious that compound fractures of the fingers, as well as many other types of finger injuries, did not receive adequate care in the hospital dispensary.

General anesthesia, nerve block at the wrist or brachial plexus was employed with satisfaction. Local anesthesia was rarely employed. Compound fractures of the fingers were usually associated with crushing injuries and edematization of the tissue, therefore local anesthesia would have placed a further burden on the tissues or even caused gangrene.

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Mechanical cleansing was the first step in the surgical care of compound fractures of the fingers. The entire hand except the wounds, was scrubbed for ten minutes with a brush, soap and water. When grease was present the scrubbing was preceded by a cleansing with benzene followed by ether. The hand was rinsed with sterile saline solution. The arm was elevated to empty the veins and a tourniquet was applied to the upper arm. The skin of the entire hand was prepared with an antiseptic, and care was taken not to permit any of it to enter the wound. The entire hand was draped with sterile linen. The surgeon, wearing a cap, mask, sterile gown and a pair of sterile gloves, continued the mechanical cleansing. The entire wound was explored. Foreign material was searched for and removed from the depths of the wound. The wound was again cleansed with copious amounts of sterile saline solution.

Careful débridement was the next step. An efficient mechanical cleansing facilitated this procedure. Tissue that had been irreparably damaged was excised. Blood vessels, nerves and tendons were preserved. At times, skin flaps which might have impaired drainage were present and they were removed in part or wholly. When the nail was involved in the injury it was completely removed to allow adequate drainage, to permit thorough cleansing, and to eradicate a source of infection.

After débridement the tourniquet was removed and bleeding vessels were clamped accurately and ligated with No. 80 cotton. The entire wound was frosted lightly with sulfanilamide crystals. The fracture was reduced. The same principles of reduction and maintenance of reduction that apply to simple fractures of the fingers were employed in compound ones.

Rarely was suturing done. Proper splinting with plaster encasements achieved a degree of wound coaptation that could not be improved by sutures which are tied without tension. Furthermore, tight closure of the wound was undesirable.

A small sterile gauze dressing was placed over the wound and the finger bandaged lightly. An unpadded encasement was applied to the finger. Holding it in the desired position the plaster bandage was made to immobilize the joint above and the joint below the fracture, in case of a fracture of the proximal phalanx, plaster was applied to the hand but did not include the uninvolved fingers.

The encasements were heavy enough to maintain reduction and protect the finger from further injury, but were not large and awkward. The most satisfactory encasements were made from the so-called "specialist splints," which are made by Johnson & Johnson. Six layers of these splints were cut to form two sugar-tong-type of splints which were applied in an anteroposterior and a radio-ulnar direction. The splints were molded together to form an encasement. By making the encasement in this manner the danger of a tight plaster bandage such as might be applied by circular turns is avoided.

The hand was elevated for several hours after operation. A prophylactic dose of gas gangrene and tetanus antitoxin was administered after the usual

skin test If the patient was not sent back to work immediately or the following day, one gram of sulfadiazine was administered every four hours

The hands were examined daily for three days The condition of the base of the finger, the regional lymph nodes, and the patient in general, were accepted as evidence of infection in the wound The encasements were removed after one to two weeks and, if necessary, another plaster bandage was applied at that time

MATERIAL

There were 37 patients, with 38 compound fractures of the phalanges All of the patients were laboring men between the ages of 18 and 61

The type of injury was severe as a rule In 35 instances the patient suffered a crushing type of injury One patient caught his fingers in an electric fan Another patient struck his finger on an emery wheel and, in addition to the compound fracture, much of the soft tissue was abraded

Table I indicates the finger involved The compound fractures involved the distal phalanx in 26 instances, the middle in six and the proximal in six

TABLE 1

FINGER INVOLVED

Thumb	6 fractures
Index finger	10 fractures
Third finger	14 fractures
Fourth finger	6 fractures
Fifth finger	2 fractures

The fractures were comminuted in 17 cases, and involved a joint in five instances There was appreciable displacement in 20 cases

Sixteen of the 37 patients lost no working time The loss of working time is given in detail in Table II because it is such an important factor in finger injuries Hospitalization was required in 11 cases, for a total of 33 days

The total cost to the insurance company was made available to the author in 26 cases The average total cost per patient was \$93.87 The highest total cost was \$379.00 The average medical cost for all the cases was \$33.25 The highest medical cost was \$77.00 The payment of compensation to the patient and the hospital costs represent the difference between the total and the medical costs

There were seven amputations Six were at the distal interphalangeal joint, and one was at the proximal interphalangeal joint There were four primary amputations Three secondary amputations were performed because of gangrene, nonunion of a fracture and a painful amputation stump due to tight flaps at the primary amputation

There was no clinical evidence of infection in any of the cases Cultures were not made

The end-results were considered good when the man returned to his

COMPOUND FRACTURES OF FINGERS

TABLE II
LOSS OF WORKING TIME

No of Patients*	No of Working Days Lost
16	0
1	1
1	2
1	3
2	6
1	10
1	11
1	15
1	18
1	30
2	32
1	34
1	38
1	39
2	40
1	50
1	54
1	188

* One patient changed jobs during his period of disability
Although his exact loss of time is not known, it is certain that he
is doing technical work similar to that which he did before injury

previous work and did it efficiently and without discomfort or hazard due to his injured finger. In every case the end-result was good.

DISCUSSION

The complete absence of infection clinically attests to the efficacy of this type of treatment which has previously proven itself so successful in the treatment of compound fractures of the larger bones. The healthy condition of these wounds is a marked contrast to the condition of finger wounds which have been given inadequate surgical care in a hospital dispensary and not splinted effectively.

The universally good functional results are important. It must be stressed again that these men are laborers and the results are measured functionally and not anatomically. The patients were able to return to their previous work satisfactorily. They had no significant discomfort in their injured fingers. The injured finger was not awkward and did not present an industrial hazard which predisposed to further injury.

The loss of working time can be profitably discussed. The 16 men who lost no days of work represent the best results. Five other patients who lost a total of 12 working days may also be regarded as acceptable results.

One patient had portions of two other fingers previously amputated and although the encasement on the injured finger would have permitted him to work, he was unable to do so satisfactorily because of the previous amputations. Another patient lost 32 days because in addition to his compound fracture he had an avulsion of a part of the fat pad over the palmar surface of the distal phalanx. A pedicle graft from the thenar eminence of the hand was applied.

Two of the earlier cases could have returned to work sooner if a more

carefully applied plaster encasement had been used. One of these men was injured on an emery wheel and had extensive loss of the soft tissues over the palmar surface of the proximal phalanx. These men lost 11 days each.

One patient lost 50 days because poor judgment was used in his initial surgical care and the distal phalanx became necrotic and had to be amputated secondarily. A primary amputation would have saved him at least 35 days. One man lost 10 days because an amputation was undertaken with tight flaps. This was an error in judgment. The insurance company paid him for the loss of the entire finger, and it was later amputated because of discomfort.

Two patients who had sustained severe crushing injuries of their fingers suffered intense pain in the ends of their fingers that suggested minor causalgia. After the wounds were healed, merely touching the fingers with cotton caused marked pain. Injection of the cervical sympathetic nerves or the appropriate peripheral nerve with procaine hydrochloride was not done, but should have been done. In more recent cases the author has had gratifying results from this procedure.

One man lost 188 days. While holding a stake his thumb was struck with a 12-pound sledge hammer. He sustained a compound fracture of the proximal phalanx of his thumb. The fracture was comminuted but the phalanx was split longitudinally into two major fragments. The fracture did not unite. He was given a choice between a bone graft and amputation preserving the viable proximal fragment. He chose the latter and is now working with a good functional result. The decision to perform a secondary amputation was postponed much too long. Probably six weeks would have been sufficient time to allow for callus formation from both major fragments. The decision to intervene would have been easier to make had he been able to work with an encasement on for about three weeks. This was impossible because of severe causalgia-like pain. Nerve block in this case might have saved much lost working time.

An emotional factor contributed to the loss of working time in five cases, who lost a total of 141 days. One man was known as a chronic job changer. He refused to work, whether he could or not, until his wound was healed. Soon after it was healed he quit his job. In one case impending induction into the army was thought to prolong disability. One man was later found to be working elsewhere while he was being paid compensation. In the two remaining cases the patients probably could have been persuaded to return to work.

The industrial surgeon must be alert to his responsibility to return patients to work as soon as they are able. Very often an intelligent discussion with the patient will allay some imaginary fear and result in a much shorter period of disability. At times it is important to call the patient's employer and determine whether there is some type of work which the patient may do despite his disability. The personnel manager of the plant has a responsibility in this procedure. If a man with partial disability is given a job where his associates must do part of his work for him, ill feeling or industrial hazard to

his fellow workmen may result. If light work must be created for the disabled man, the cost may be higher than that of compensation.

Encasements for injured fingers have been extremely successful in the author's experience. They achieve perfect splinting and complete rest for the finger. With the use of encasements all finger nails involved in the injury are completely removed. The plaster bandage provides a better splint than the injured nail and avoids any disability due to the loss of the nail. Furthermore, with the removal of the entire dirty nail a source of infection is eradicated.

Probably the greatest advantage of the encasement is the prevention of further injury. It is this factor which the patients appreciate most for they can work painlessly while the finger is healing. They often volunteer their appreciation for the plaster bandage and frequently ask for another one to be applied when the time to discontinue immobilization comes.

The simple technic of application of encasements to fingers has been described. It is worth emphasizing that the encasements are formed of molded plaster splints, which procedure avoids a tight plaster bandage that might result from its circular application. With a little practice encasements which will give perfect immobilization and protection from further injury, and yet not be awkward, can be made. Plaster encasements are easier and quicker to apply than wooden or metal splints. They are more efficient and more comfortable than such splints. No difficulty with tight encasements or stiffness of fingers due to them has been encountered. They can be removed easily with a heavy pair of bandage scissors. In the early cases men sometimes asked to have plaster bandages removed because they were dirty. Covering the encasements with cotton or leather stalls while working solved this problem.

The use of encasements on injured fingers is part of the infrequent dressing technic. The dressings are done at intervals of one to two weeks. This procedure saves time, money and discomfort to the patient. It prevents secondary wound infection.

It is very gratifying to the patient and doctor to see the healthy or healed wounds when the encasements are removed. It is obvious at this time that sutures (tied without tension) would not have resulted in better wound coaptation than the encasements afforded. Furthermore, sutures would tend to act as foreign bodies and impede drainage.

In addition to compound fractures, encasements have been applied frequently for simple lacerations and infections of the fingers. In such cases they have been very successful and have been the deciding factor between the man working and not working. Lacerated fingers are rarely sutured because here, too, encasements have afforded as good skin coaptation as sutures.

The question of amputation often arose. Discussion of all the factors involved in finger amputations does not lie within the scope of this paper. Any surgeon treating finger injuries must be familiar with the intricacies of amputation, including the proper levels for the various fingers and the technical points which will result in a painless, useful stump. The reader is referred to the excellent articles by Couch³ and Oldham⁴ on finger amputations.

In finger amputations, the old maxim, "save all you can," is not tenable for the results in working men are measured functionally and not anatomically. If an amputation is not performed when one is clearly indicated, the wound may heal kindly but the patient will have a finger which is an industrial hazard and a cause of suffering or further injury to him. The insurance company will pay him for the loss of such a finger and to be rid of his disability he will have it amputated later. Such a complication increases the loss of working time and the cost of treatment.

Crush injuries of the distal phalanx are often amputated because of the fear of gangrene. With the closed-plaster technic, surprisingly few are not viable and do not give a good functional result.

A logical criticism of this report might be that 26 of the 38 compound fractures involved the distal phalanx and since loss of this phalanx results in no handicap to the patient,⁵ all these fractures might better have been treated by primary amputation. Usually, however, the crush type of injury which caused these compound fractures did not leave sufficient soft tissues for satisfactory flaps for disarticulation at the distal interphalangeal joint, and an amputation higher than this joint would have been necessary to avoid tight flaps and secondary amputation. Even if some of the cases had had a satisfactory disarticulation at the distal interphalangeal joint, it is doubtful if their loss of working time would have been shortened and the results would not have been better since in all the reported cases the functional results were good.

Compound fractures of two phalanges with shattering of the joint between them yield poor functional results and primary amputation should be undertaken.

It is often recommended that compound fractures of the fingers associated with a severed tendon be subjected to primary amputation. This is not always true. The author had one such case which was not amputated and a good functional result was obtained. This patient does skilled labor.

The cost of finger injuries is not insignificant. An average total cost of \$93.87, and an average medical cost of \$33.25 represent sizable amounts when the total number of cases is considered. A survey made by the author at one plant, for the year 1942, showed finger injuries to represent 19 per cent of all injuries, and to be the most costly group. If the industrial surgeon is to discharge his duty he must be alert to methods of treatment which will give a good end-result, with a minimum loss of working time and cost of treatment.

A note about sulfanilamide sensitivity is worthy of mention. Sensitivity should be suspected when the wound weeps a thin, serous drainage in copious amounts. Recently I had a simple laceration that showed such a discharge. The encasement became saturated and had to be changed. My first impression was that a serious infection was developing. Consultation with a dermatologist led to the discovery of the true condition, and when sulfanilamide was omitted, the wound healed promptly.

CONCLUSIONS

1 When compound fractures of the fingers receive the same painstaking care which similar fractures of the larger bones do, the results are good. The so-called closed-plaster method of treatment was successfully applied to compound fractures of the fingers. The technic was described.

2 Loss of working time is an important national problem in the present war. Finger injuries account for a significant loss of working time among laboring men. It is the traumatic surgeon's duty to employ forms of treatment which, in addition to giving a good final result, will result in the least industrial loss of time. The closed-plaster technic is such a form of treatment. The encasements assure the fingers complete rest and protect them from further injury. The working men like the encasements because they can return to work with no discomfort long before the wound is healed. Of the 37 patients reported, 16 lost no working time. In the remaining cases the loss of working time was analyzed to determine how it might have been reduced.

3 Finger injuries are expensive, especially when their frequency is considered. In the present series the average total cost per case was \$93.87, and the average medical cost per case was \$33.25. Surgeons must be attentive to compensation costs, for they are reflected in manufacturing costs. The closed-plaster technic for compound fractures of the fingers is less costly than other methods of treatment, as the men return to work earlier and dressings are done less infrequently.

4 The results of the closed-plaster method of treatment in 38 compound fractures of the fingers were good. In no case was there clinical evidence of infection. In every case the functional result was such that the man was able to return to his previous work and do it efficiently and without discomfort or hazard due to his injured finger.

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REGIONAL ENTERITIS INVOLVING MECKEL'S DIVERTICULUM

PERFORATION OF THE DIVERTICULUM AND FISTULA FORMATION

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REGIONAL ENTERITIS has a predilection for the terminal ileum, as Crohn, Ginzburg and Oppenheimer¹ pointed out in their original description of the disease. Other reports of nonspecific granulomas of the intestinal tract, however, indicate that the same pathologic process may involve any segment of the bowel from the duodenum (Gottlieb and Alpert²) to the sigmoid (Dalziel³). Furthermore, Ravdin and Rhoads⁴ have pointed out the similarity of fibroplastic appendicitis to this process. Meckel's diverticulum only once (Barrington and Norrish⁵) has been a site of the disease and never before has been the point of fistula formation in regional enteritis. For this reason it seemed of interest to record the following case.

Case Report—Hosp No 55860 E C, white, female, age 23, married. The patient had experienced pain in the right lower quadrant of the abdomen at intervals since the birth of her first child three years ago. The pain was accompanied by tenderness and the attacks usually lasted from one to three days. They increased in frequency and severity until three months before admission. It was decided that celiotomy be performed. This was carried out July 10, 1943, at the Good Samaritan Hospital, Lebanon, Pa, through the lower right rectus incision. A large mass was found involving the cecum, terminal ileum, right tube and ovary, all of which were densely adherent to each other. There was marked induration of the mesentery. The tube on the right side was inflamed and the ovary was the seat of a large chocolate-colored cyst. The tube, ovary and appendix were removed. Sulfanilamide was placed in the wound, and Penrose drains introduced.

Following this procedure the patient recovered satisfactorily, but continued to drain purulent material. She was referred to the Hospital of the University of Pennsylvania by her physician, Dr Clyde Saylor, and admitted on September 25, 1943. The past and family histories were noncontributory. She was a housewife.

Physical Examination—The patient, a well-developed and well-nourished woman of 23, who was rather pale. Temperature, 98.4° F, pulse, 87, respirations 16, blood pressure, 104/68. Examination was essentially negative except for the abdomen. There was a five-inch right rectus incision with a drainage tract near the midpoint discharging small amounts of creamy pus. At the level of the umbilicus there was a vague rounded mass on the right side. This area was moderately tender. Peristalsis was normal.

Laboratory Data—Hemoglobin 78 per cent. Leukocyte count 7,200. Flat film of abdomen. Negative. Barium enema. Uncertain, in that it was thought that part of the cecum failed to fill.

Preoperative Diagnosis Infected mesenteric cyst. The patient was given three grams of sulfadiazine in preparation for operation.

Operation—September 28, 1943. Under continuous spinal anesthesia, the old wound was reopened and extended upward. Here the peritoneum was entered. Two adherent

REGIONAL ENTERITIS

loops of small bowel were dissected free from the anterior abdominal wall. Between them a Meckel's diverticulum was found which was adherent to the mesentery. It was freed and found to have a perforation at its tip. It was rapidly removed and the ileum closed. Further exploration then showed that the cecum and terminal ileum were inflamed and thickened and were matted down against the pelvic brim. They were mobilized as was the remainder of the right side of the colon. About two feet of small bowel and the right half of the colon were resected. A side-to-side anastomosis of the transverse colon and the ileum was made.

Pathologic Examination—The gross specimen consisted of a segment of large and small intestine and the separately excised diverticulum. The intestinal segment included 59 cm of the terminal ileum, the cecum and approximately 10 cm of the ascending colon.

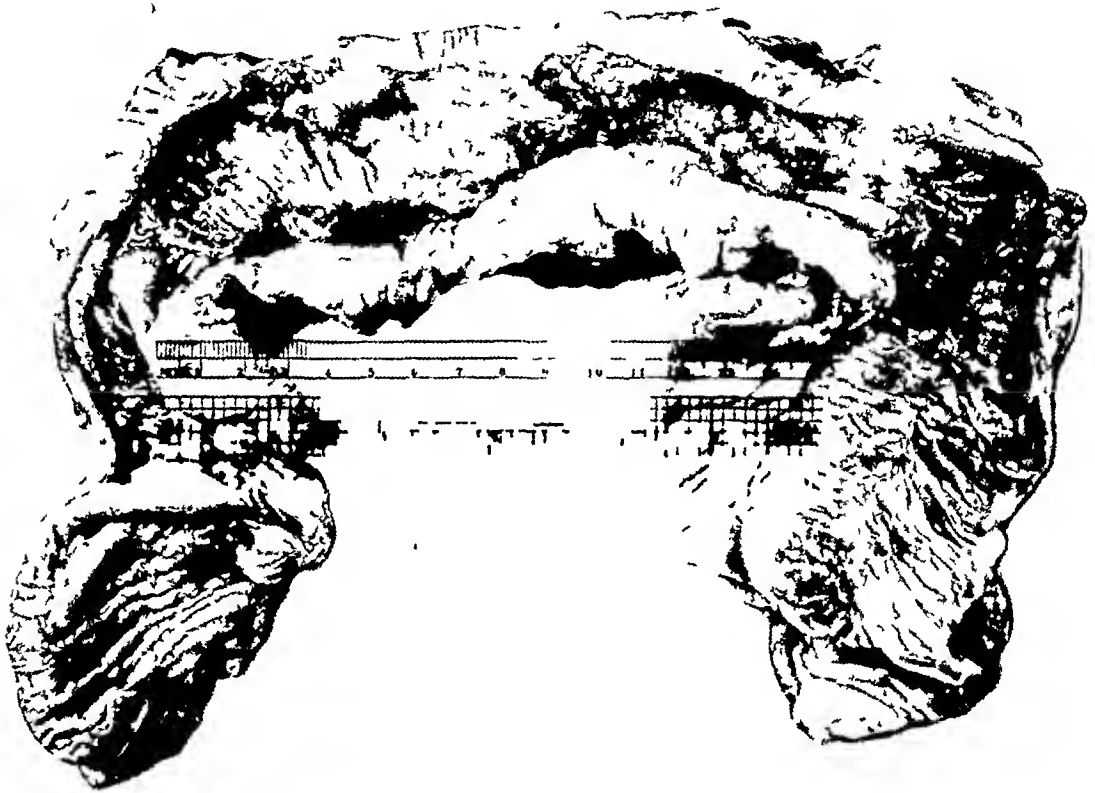


FIG 1—Regional enteritis of terminal ileum, cecum and ascending colon. The photograph does not include the proximal half of the resected small intestine.

The appendix had been removed previously. The wall of the distal part of the ileum, especially the muscularis, was rigid and greatly thickened. This produced a considerable degree of stenosis in the terminal 8 cm. The mucosal surface was diffusely reddened and granular, and the folds were either thickened or lost. Usually extending longitudinally along the mesenteric border were a number of superficial, more or less rectangular ulcers. Their edges were irregular and frequently overhanging and their craters were filled with mucoid material. The largest ulcer was 4 cm long and 0.6 cm wide. These pathologic changes were marked only in the distal 20 cm of the ileum, but they extended in diminishing intensity and patchy distribution, proximally for about another 20 cm. The ileocecal valve was strikingly thick and rigid, and a few tiny ulcers were present on its cecal aspect. A small portion of the adjacent large intestine was also involved (Fig 1). The site of excision of the diverticulum was found 40 cm from the ileocecal valve at about the proximal limit of evident disease. The ileal mesentery was thickened and contained a number of enlarged, soft lymph nodes.

The diverticulum was conical, measuring 1.5 cm in diameter at its base and 3 cm in length. Its wall resembled that of the less intensely involved portions of the ileum. The perforation at its tip was 2 to 3 mm in diameter, and the edges were red, granular, and somewhat indurated. Scarring was not extensive and there was no ulcer crater, except for the perforation itself.

In addition to hyperemia, muscular hypertrophy, and ulceration, microscopic examination revealed considerable degrees of fibrosis and cellular infiltration, most marked



FIG 2—Photomicrograph of terminal ileum showing submucosal fibrosis and an inflammatory cell infiltration which extends into the mucosa and the muscularis. The edge of a superficial ulcer is at the right ($\times 24$)

in the submucosa and somewhat less so in the subserosa (Fig 2). The inflammatory cells were of varied type, neutrophil leukocytes predominating in the areas of ulceration, lymphocytes, plasma cells, and larger mononuclear cells predominating elsewhere. Large lymphoid follicles were numerous. Occasional giant cells were seen but neither these nor pseudotubercles were a conspicuous feature. The histopathologic changes were of

REGIONAL ENTERITIS

the same nature in all the parts of the intestine involved, although they varied in degree. In general, they were less intense in the diverticulum (Fig 3), the cecum, and the proximal part of the small intestine, than in the terminal ileum. This is particularly true with regard to the fibrosis. The mucous membrane of the diverticulum was of the small intestinal type. No heterotopic tissue was found in numerous sections. The perforation was lined by granulation tissue containing many neutrophil leukocytes as well as mononuclear cells, but scarring was not extensive. The lymph nodes showed a non-specific hyperplasia.



FIG 3—Photomicrograph of Meckel's diverticulum showing intestinal type of mucous membrane and a nonspecific, chronic inflammatory reaction. This section was taken from an area adjacent to the perforation. ($\times 32$)

COMMENT—Much has been written about the pathologic changes that may occur in association with Meckel's diverticulum. Perforation is not an unusual event, occurring as a sequela to ulcer or acute diverticulitis with gangrene. The ulcers found in Meckel's diverticula are usually regarded

as peptic (Greenwald and Steiner⁶), although Winkelbauer⁷ believes them to be caused by spasm of the diverticula. They may be situated either in intestinal or gastric mucous membrane but in the great majority of cases in which microscopic examination was carried out, heterotopic gastric mucosa has also been demonstrated to be present (Schullinger and Stout⁸). In our case heterotopic tissue was not found after careful study of numerous sections of the diverticulum. Nor did the gross or microscopic appearance of the perforation suggest a similarity to the usual chronic ulcer of the stomach or duodenum. The mucosal linings of the majority of Meckel's diverticula are of the intestinal type, heterotopic tissue being found in only 15 to 25 per cent (Greenblatt, Pund, and Chaney⁹). The possibility that the diverticulum in our case was acutely inflamed at the time of the first celiotomy cannot, of course, be completely ruled out, but the pathologic changes in the diverticulum are entirely similar to those in the ileum, differing only in degree. They do not suggest the previous occurrence of acute diverticulitis and gangrene, nor does the clinical history. Furthermore, the pathologic examination indicates that the disease in the terminal ileum was more advanced than that in the diverticulum and the more proximal part of the small intestine. This sequence of events—inception of the disease in the terminal ileum with progression proximally, perforation, and following appendectomy, fistula formation—as well as the gross and microscopic appearance of the lesion, corresponds closely to the original description of Crohn, Ginzburg and Oppenheimer,¹ which has since been confirmed by others.¹⁰

SUMMARY

A case of nonspecific regional enteritis involving Meckel's diverticulum is reported. A fistula had developed following a previous appendectomy and right salpingo-oophorectomy, and a perforation was found in the diverticulum. The patient recovered following a resection and anastomosis.

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BRIEF COMMUNICATIONS

A PARAUMBILICAL ABDOMINAL WALL CYST*

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THE FINDING of an unusual cyst in the abdominal wall of a patient prompted an investigation to determine its true nature and etiology, if possible. Certain data have been obtained which make the case of special interest.

Case Report—G. R., colored, female, age 47, entered the Barnard Free Skin and Cancer Hospital, January 14, 1943. For seven or eight years she had known that she had a uterine tumor. This had not disturbed her until one year before admission. It had then begun to grow quite rapidly and subsequently produced a protuberance in her abdominal wall. The gravid appearance rather than pressure symptoms from the growth motivated the patient to ask for its surgical removal.

The patient reported her past health as having been good. She had received therapy for syphilis. She had never been operated upon.

The menstrual history was interesting in the light of later findings. Her periods were always regular and had been 28 days apart since menarche at age 13. Her last menstruation had been three weeks prior to admission. She had experienced neither menorrhagia nor metrorrhagia. The patient had been pregnant seven times—having had four miscarriages and three term births.

Physical Examination—The patient was an alert, well-developed and well-nourished colored female. The examination revealed as significant data: A saddle nose, a blood pressure of 158/90, a definitely enlarged abdomen which contained a firm, movable mass at the level of the umbilicus, a liver edge which could be palpated three finger's breadth below the right costal margin, and a uterus, definitely enlarged and irregular in outline, which was obviously connected with the abdominal mass. The laboratory examinations revealed no abnormalities. The Kahn test was negative. *Pathologic Diagnosis*: Pedunculated fibromyomata uteri.

Operation—January 16, 1943. An abdominal hysterectomy was performed under spinal anesthesia (pontocaine, 20 mg). While extending the lower midline incision to the left of and superior to the umbilicus, a cystic structure was exposed in the subcutaneous layer of the abdominal wall. This was not given careful consideration until the abdominal wall was being closed.

Numerous large, pedunculated masses filled the abdominal cavity. These were connected to a stalk which was attached to the uterine fundus. (One of these had obviously been mistaken for the liver, as this organ could not be seen until after the mass had been displaced anteriorly.) After cutting several thick, fibrous adhesions which anchored two of the masses to the posterior abdominal wall, the entire specimen was delivered through the wound. At this point the patient's blood pressure fell markedly. It was necessary to administer supportive measures (intravenous fluids and stimulants) which were effective. A hurried supracervical-type of hysterectomy was performed—the right adnexa being taken while the left were allowed to remain.

During the closure of the abdominal wall, the cystic mass was excised. It was situated approximately one inch superior to the umbilicus and was immediately superficial to the linea alba.

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Gross Pathology—The intra-abdominal specimen weighed eight pounds. It consisted of the uterus, the right tube and ovary, and the bulky pedunculated fibromyomatous masses, which were attached to the fundus of the uterus by a relatively narrow pedicle. The uterus proper was about twice normal size. Submucous, intramural and subserous masses distorted its shape and all but obliterated its cavity. Several moderately-sized serous cysts were attached to the stalk. Numerous white shreds were scattered over the surface of several of the tumors. Close inspection revealed that these were made up of minute spherical masses not unlike "fish roe" in appearance.

The abdominal wall specimen measured 15 x 2 x 3 cm. It had the appearance of a cyst, being of grey color with purple mottling. When the specimen was bisected, it was found to be a two-chambered structure (Fig 1). A smaller cavity was situated within a larger one. They shared one wall in common. The arrangement was that of a "cyst within a cyst." The outer space contained small homogeneous white ovoid bodies, which were attached to one another. They were considerably larger but otherwise quite similar to the "fish roe" strands seen on the surface of the abdominal tumors. The smaller space contained a thick brown fluid.

Microscopic examination of the sections taken from the uterine masses revealed nothing more than the fibromuscular stroma so characteristic of fibroid tumors of the uterus. The fibrous tissue elements predominated.

A sufficient number of the white shreds were collected from the surfaces of the abdominal masses to embed and make a block for microscopic study. The microscopic appearance of the preparations made from this was that of a homogeneous pink-staining ground substance through which were scattered a moderate number of basic-staining nuclei. A single layer of flattened cells formed a covering for each of the many irregularly-shaped masses composing the section.

The wall of the abdominal wall cyst is made up of fibrous connective tissue. It varies in thickness, being relatively thick where the two cavities have a common wall but being much thinner elsewhere. Fibro-areolar tissue and a small amount of fat is to be found in some areas. The thickest portion of the wall is fairly well vascularized. Exterior to the single layer of fibroblastic cells, which form the lining of the larger space, is a shallow zone of elastic fibers. The contents of this cavity are composed of irregularly-shaped masses of homogeneous pink-staining material having a waxy texture. The microscopic appearance of these bodies is identical with that of the material collected from the surfaces of the fibromyomata.

The small cavity has a wall similar to the large one. The finding of a lining epithelium sets it apart from the outer one. In some areas the epithelium is seen to be cuboidal in type, but generally speaking, it is composed of pseudostratified ciliated columnar cells (Figs 2 and 3). The basement membrane is smooth for the most part, but the epithelium is raised into papillary folds in a few places.

DISCUSSION—The proximity of an abdominal wall cyst to the umbilicus suggests the possibility of its origin from a vestigial remnant. Cullen¹ in his authoritative treatise, does not describe a similar structure as being superior to the umbilicus and superficial to the anterior sheath of the rectus abdominis muscles.

If the patient had previously had an abdominal operation, one could surmise that a fimbria of an oviduct had accidentally been transferred to the abdominal wall. Since she had had no operation, this precluded such a speculation.

There is not any possibility of the cyst being metastatic from the intra-abdominal tumors nor a direct extension from them. The histopathology of

FIG 1—The inner, epithelium lined, cavity of the abdominal wall cyst is clearly seen in the photograph of the bisected specimen. The small, white inclusions of the outer cavity appear rather indistinctly in the upper right part of the photograph (Approximately actual size)



FIG 1

FIG 2—A low power photomicrograph reveals the transition from low columnar to the pseudostratified columnar type of ciliated epithelium

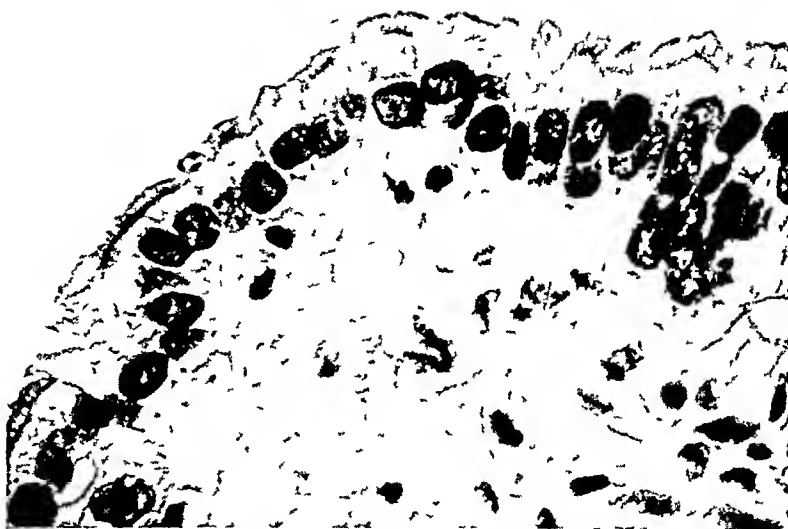


FIG 2

FIG 3—A high power photomicrograph affords a more detailed view of the epithelium showing individual cilia

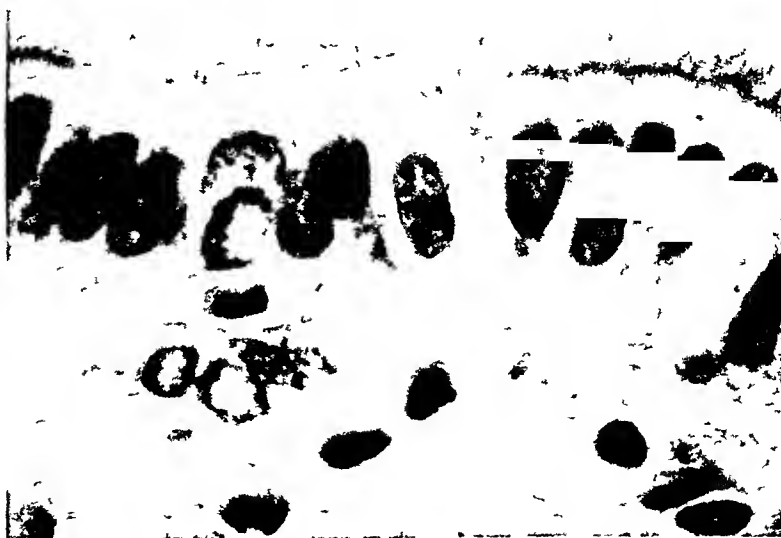


FIG 3

the cyst precludes its direct or indirect relationship with the intra-abdominal fibroids

A detailed study of the lining epithelium was made in the hope that it might be of help in drawing conclusions. Pseudostratified ciliated columnar epithelial cells normally occur only in the respiratory tract and the genitourinary system. Dr E V Cowdry was kind enough to study these cells with me. He believed them to be true ciliated cells, but suggested that Dr Alfred M Lucas be asked to give an opinion in this regard. Doctor Lucas concluded that the cells are ciliated and do not have a striated cuticular border. He found only one basal body on each cilium. This is the situation found in nasal epithelium. The ciliated cells of the fallopian tube have a diplosome-type of basal body. A preparation was stained with hematoxylin and mucicarmine in an effort to determine the presence of mucus secreting cells. None were detected, but this, in itself, does not rule out a similarity to respiratory epithelium.

Dr George W Corner, who also kindly reviewed the slides from the embryologic point of view, concluded that, in all probability, the mass represents an atypical differentiation of local origin (teratoma).

Doctor Cullen graciously responded to say that in his belief, the structure most probably was derived from a remnant of the omphalomesenteric duct.

These varying opinions preclude a dogmatic statement as to the origin of the cyst. The presence of identical masses, scattered over the surface of the abdominal tumors on the one hand and being contained within the outer cavity of the cyst on the other hand, suggests a possible relationship between the two pathologic processes.

SUMMARY

The case history of a colored female patient is given. An interesting cyst was accidentally found in her abdominal wall (superior to the umbilicus and superficial to the linea alba) while performing an hysterectomy. One may not dogmatize regarding the specific etiology of this cyst. The opinions of authorities are given.

REFERENCES

- 1 Cullen, Thomas S. *The Umbilicus and Its Diseases*, 1916, W B Saunders Company, Philadelphia.

MULTIPLE ADENOMAS OF THE JEJUNUM

CASE REPORT

W B DICKSON*, M D , F R C S (ENG)

UTICA, N Y

FROM THE SLOCUM DICKSON CLINIC, UTICA, N Y

THE FOLLOWING CASE IS reported to record the occurrence of multiple adenomas of the jejunum. There was also an associated adenoma of the colon.

Tumors of the small intestine are not common. Somewhat less than 50 per cent are malignant, *i e*, lymphoblastoma, carcinoma, and sarcoma, in order of frequency. The benign tumors encountered are adenomas, argentaffin tumors, lipomas, myomas, fibromas, and miscellaneous other rare types. Adenomas are the most common benign tumors and are found more frequently as a single tumor than multiple. Since they arise from the inner bowel layers, they protrude into the bowel lumen and assume a polypoid form of more or less degree, a significant fact in their symptomatology. Their location may be anywhere, but the greatest frequency is in the ileum, second, the duodenum, and third, the jejunum. All reports agree that adenoma of the jejunum is a rare condition.

The association of small bowel adenomas with adenomas of the colon does occur. In multiple polyposis of the colon the adenomas may extend to the lower ileum. However, the association of adenomas of the jejunum and colon is another matter, and I have been able to find only one instance (recorded by Gerwig and Stone, in 1943), of a single jejunal adenoma associated with multiple adenomas of the splenic flexure of the colon.

The clinical course of the patient to be reported has been followed over a period of 11 years, and serves to emphasize the following features:

(1) The obscure nature of the symptoms associated with small bowel tumors. These may suggest gallstone colic, renal colic, peptic ulcer or even a primary anemia. Intussusception is a common complication. Celiotomy for intestinal obstruction reveals the true diagnosis very often for the first time.

(2) Intussusception in the adult is always secondary to some underlying condition.

Case Report—A slim, red-headed female, single, age 22, was first seen in August, 1932, with acute right lower quadrant abdominal pain and vomiting. There was a past history of an operation for "telescoped bowel" at age seven. In addition she described peculiar attacks of abdominal pain and vomiting occurring once or twice a year since the age of 17. The present attack was similar to these, but more severe. On abdominal examination, there was some muscle resistance and an ill-defined tender mass in the right lower quadrant. On vaginal examination, there was another distinct mass,

*Lieutenant Commander, M C , U S N R

The views expressed herein are the writer's and are not to be construed as official or reflecting the views of the Navy Department.

the size of an orange, in the left fornix. The temperature was 100° F, and catheterized urine showed albumin and RBC. Following an enema the symptoms were relieved and the right-sided abdominal mass disappeared. Intravenous pyelography showed a stone in the right kidney. This was accepted as the cause of her symptoms and the stone removed ten days later. Recovery was uneventful and she left hospital symptom-free. Within a few weeks her old attacks of abdominal pain recurred. These were commonly not much more than "cramps" referred to the umbilicus, and occurred at intervals of days to weeks. Vomiting was unusual. Roentgenologic examination of the G U tract and gallbladder were normal, and the urine was clear.

In July, 1933, she developed a much more severe attack than usual and was brought to the hospital. A tender sausage-shaped mass was palpable in the midabdominal region. An enema produced results but no relief. Exploratory celiotomy disclosed an intussusception of the upper jejunum, ten inches in length, which was readily reduced. On searching for a cause a polypus, the size of a marble, was noted at the site of the intussusception, while above it were several smaller ones, and still higher, and about 12 inches from the duodenal jejunal flexure, a side-to-side anastomosis marked the site of the operation in childhood. Tracing the bowel downward from the intussusception, three or four small polypi were recognized, and finally one, the size of a walnut, was encountered about at the juncture of the jejunum and ileum. Below this there were none. The upper polypus causing the intussusception was removed by simple incision, ligation of the pedicle at its attachment to the mesenteric border, and closure. A similar process was attempted with the large polypus in the lower jejunum but the slipping of a clamp and hematoma formation necessitated resection and end-to-end anastomosis. The smaller polypi were not interfered with, and the abdomen was closed. Recovery was uneventful.

A postoperative (August, 1933) barium meal showed stomach and duodenum normal, the jejunum shortened, widely dilated, and the lumen almost filled by mucous membrane, thrown into deep folds between which only flecks of barium remained. Two ring-like formations were present, which were suggestive of polypi in the lower portion. The ileum appeared normal, and there was no evidence of delay or obstruction at any point.

Attendance at the Clinic during the next four years, 1933-1937, was sporadic. The chief complaints were continuing attacks of crampy abdominal pain and vomiting at intervals of weeks to three or four months, minor episodes of diarrhea, although the bowels were usually regular, occasional blood in stools, and general debility. The weight remained stationary at 107 lbs. Examination was negative except for moderate secondary anemia, and the mass in the left vaginal fornix. Menstruation was regular. Rectal and sigmoidoscopic examinations were negative. She was able to carry on her work in a factory satisfactorily.

In September, 1937, she again developed a severe attack of abdominal pain and vomiting, and was brought to the hospital. Abdominal examination showed a sausage-shaped midabdominal mass. Manipulation was attempted in the hope of external reduction. Considerable decrease in size resulted, but as no reliance could be placed on this, celiotomy was carried out. No intussusception was found. However, about three feet from the duodenojejunal flexure an 18-inch segment of jejunum was markedly dilated and edematous. Immediately at the upper margin of this area two polypi, the size of marbles, were palpable, and at the lower border one of the same size. The interpretation was that this was the site of an intussusception reduced by the preoperative manipulation. A thorough exploration of the whole G I tract was then carried out. The stomach and duodenum were normal, with no evidences of polypi. The first 12 inches of the jejunum was markedly "mushy," as if from redundant mucosa. No actual polypi were recognizable. Immediately below this was the side-to-side anastomosis, performed at age seven. Three feet below the flexure were the two polypi noted above,

MULTIPLE ADENOMAS OF JEJUNUM

and in the 18-inch loop of edematous jejunum, and at its lower margin, was the third polypus. From this point to the lower jejunum were four or five small polypi, and then the site of the end-to-end anastomosis, of 1933, was encountered. Below this the ileum was normal. Following the large bowel downward it was found to be normal to the middle of the transverse colon, where a polypus, the size of a walnut, was found. All



FIG 1—Three adenomas removed at 1937 operation



FIG 2—Photomicrograph of adenoma shown in Figure 1

polypi, including this one, had the characteristic of being attached to the mesenteric border by distinct pedicles. The remaining colon and rectum were entirely normal.

The two polypi above and one below the segment of edematous bowel were removed through small incisions. The other small bowel polypi were not interfered with. When the sigmoid and rectum were palpated for polypi the pelvic tumor was

noted. It was delivered and found to consist of a solid tumor and a cyst, each the size of a small orange, arising from a common pedicle and replacing the left ovary. These were removed. The uterus was noted to be enlarged and smooth. It was felt removal of the colon polypus should not be attempted at this time. The abdomen was closed in layers. Recovery was uneventful.

The subsequent clinical course of the patient was complicated by the fact the ovarian tumor proved to be a malignant granulosa cell tumor of the ovary, which eventually showed evidence of metastases (April, 1941). These, however, responded well to roentgenotherapy, and she is still in fairly good health today. A barium enema, in October, 1937, demonstrated the single polypus in the transverse colon, which was otherwise normal.

As far as the intestinal adenomas were concerned, the patient continued to have attacks of abdominal cramps and vomiting at various intervals, and of varying intensity, but, on the whole, of minor degree. There have been also minor episodes of diarrhea and, at times, gross blood in the stools. There has been a definite tendency to anemia. Removal of the colon polypus was urged from time to time (until the problem of metastatic malignancy from the ovarian tumor arose), but consistently refused.

Probably the diarrhea and gross blood in the stools can be attributed to the colon polypus. The episodes of abdominal pain and vomiting may have been due to either the large or small bowel tumor. There was no consistent association between these two occurrences, *i.e.*, diarrhea, the abdominal pain and vomiting.

The secondary anemia was certainly contributed to by the colon polypus although the small bowel tumors may also have been a factor.

SUMMARY

The clinical course over a period of 11 years of a case of multiple adenomatous polypi of the jejunum, associated with an adenoma (probable) of the colon, has been recorded. Episodes of abdominal pain and vomiting, of varying intensity, were characteristic. The more severe attacks were associated with intussusception and required operation. It is possible that even in minor attacks intussusception of some degree occurred and were relieved by spontaneous reduction. Low-grade secondary anemia was a well-marked feature.

In spite of all these handicaps this patient is alive, enjoys relatively good health, and when last heard from was attempting to enlist in the
W A C S

EDITORIAL ADDRESS

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FORUM

(Articles published in the ANNALS OF SURGERY do not necessarily represent the opinions of the editors, even though they are selected and published with editorial approval. Likewise, the editors may not necessarily be in agreement with correspondents whose communications are important if only because they present stimulating opposition. Since this impartial point of view is vital to progress in science, the ANNALS OF SURGERY offers this forum for pertinent discussions of reasonable length—Ed.)

Re Discussion by Kellogg Speed, M D of article by D E Robertson, M D appearing in ANNALS OF SURGERY, 118, 318-328, August, 1943

ABRAHAM O WILENSKY, M D, NEW YORK, N Y.

"The discussion on Dr D E Robertson's paper in the August ANNALS OF SURGERY, on Osteomyelitis made by Dr Kellogg Speed, carries the following statement in reference to the work of Wilson and McKeever, namely, that 'Together with Wilensky, they still favor operation for established osteomyelitis' I am rather surprised at this because I have always tried to make it clear that the only two indications for operation which I have ever made were (1) the presence of a frank abscess in the soft parts which is anatomically within surgical reach, and (2) the removal of a sequestrum which is acting as an irritating foreign body. I have always favored leaving the cure of the osteomyelitis to nature except for these two indications."

Rebuttal to the Objections of Doctor Wilensky

KELLOGG SPEED, M D, CHICAGO, ILL

"In the discussions before the American Surgical Association, there is a limited time for speaking and in my discussion of Dr Robertson's paper, I simply grouped Wilensky with the other authors as favoring operation for established osteomyelitis, as he quoted. This is in direct contrast to the complete and sole efforts at treatment by sulfa drugs without ever any operative procedure as advocated by Robertson in his paper. The discussion time did not allow of amplification of my statement nor qualification of the operations that were practiced or suggested by authors, and so the expression may not have seemed very clear to Dr Wilensky.

"I had considerable acquaintanceship with Dr Wilensky's monograph entitled 'Osteomyelitis: Its Pathogenesis, Symptomatology and Treatment' issued in 1934, and knew full well that he did not approve of immediate attack of the bone focus in the light of the fact that blood infection was known to be present. Beginning on page 195 of this monograph these points are covered in the paragraph on treatment in which he says, I quote 'In a very small minority of the cases with very severe forms of general infection associated with an acute osteomyelitis, the clinical picture does not seem to carry with it that sudden overwhelming of the organism with a fulminating toxemia. In such cases the local bone focus deserves some attention, etc.' There are similar and other expressions in his excellent monograph covering operative treatment with removal of the whole bone, such as the clavicle, drainage of abscess, removal of sequestra, which fall under the head of operative procedures. On page 199 he mentions that ample drainage should be secured even though removal of the thrombophlebitic focus in the bone is not technically feasible. This and other statements in his book are references to operative treatment which under these restrictions are different from absolute nonoperative interference under any conditions.

"In addition, he has written other articles, some of which are iterations on his work in the monograph.

- "1. Value of Chemotherapy in Treatment of Osteomyelitis. Archives of Surgery, 44, 234-259, February, 1942. In this article he cites a boy with osteomyelitis of the tibia, not cured by sulfa drugs, but who was helped, and possibly restored to health, by operation involving excision of the saphenous vein, after which the wound was prepped open and thus left. This certainly is an operation.
- "2. Chemotherapy in Osteomyelitis. American Journal of Surgery, 57, 76, July, 1942. In this article he believes that chemotherapy has little effect on the local bone disease on account of thrombophlebitis and its plugging effects which block action of the drug, and cites again this boy on whom he performed an excision of the saphenous vein, the large operative wound left open.
- "3. Role of Chemotherapy in Treatment of Acute and Chronic Hematogenous Osteomyelitis. Medical Record, 1541, 344, November 5, 1941. Similar statements are made.

- "4 Excision and/or Proximal Ligation of Extra osseous Thrombophlebitis in Treatment of Acute Hemotogenous Osteomyelitis with Positive Blood Culture *Surgery*, 10, 409, September, 1941 This is the famous case where he ligated the extra osseous thrombophlebitis following osteomyelitis located in the tibia in a 12 year old boy, who had been given sulfa drugs previously. In contrast to Robertson's idea of no operation under any condition, I would class this as operative procedure in the brief reference I was able to make to it in the discussion
- "5 Osteomyelitis of Pelvic Girdle, *Archives of Surgery*, 37, 371-400, September, 1938 On page 396 he states in the first type "operation, often a simple incision of a frank abscess, must necessarily be done in the advanced stage of development of the lesion" For osteomyelitis of the second type surgical treatment of some kind is given' By these he meant drainage, osteotomy or sequestrectomy
- "6 Osteomyelitis of Scapula *Surgery*, 3, 21-33, January, 1938 Here Dr Wilensky advises conservative attitude 'limiting one's operation in the beginning to the incision and drainage of frank abscesses and of not interfering with the bone structure'
- "7 Acute Hematogenous Osteomyelitis with Classification, etc Results of Operation and Treatment *Archives of Surgery*, 34, 320-336, February, 1937 He speaks against local operation as curative but mentions that it might stop the spread of infection, especially from secondary foci 'The treatment of the local lesions of the bone is a problem by itself In the presence of a general bacterial infection, the latter naturally must be taken into account In the absence of any demonstrable evidence of a general bacterial infection, the method of treatment of the local lesion is to be decided in its own merits, as determined by the pathogenesis, by the biologic and anatomicopathologic development and by the physical characteristics of the total resultant lesion'
- "8 Case of Hematogenous Acute Osteomyelitis with Spontaneous Recovery *Surgical Clinics of North America*, 15, 495-500, April, 1935 The incidents occurred before sulfa drugs were used Recovery without operation
- "There was absolutely no intention on my part to mislead anyone as to Dr Wilensky's attitude on this important subject, nor did I speak without full knowledge of his many and laudable articles The difficulty of his interpretation may be attributed to the lack of space for amplification and the understanding of thorough demarcation between absolutely no operation, with benefit of sulfa drugs, and operation of any kind"

ANNOUNCEMENT

ADVISORY BOARD FOR MEDICAL SPECIALTIES

Announcement is made that the Directory of Medical Specialists is now to be published by the A N Marquis Company of Chicago, publishers of "Who's Who in America" Previous editions have been published for the Advisory Board for Medical Specialties by the Columbia University Press of New York City

It is planned not to issue the next edition before 1945, on account of the war, but the A N Marquis Company will publish a supplemental list of all those who have been certified by the American Boards since the last (1942) edition of the Directory, totaling about 3600 This is to be distributed at cost, and monthly or bimonthly bulletins listing successful candidates for certification at examinations during the additional interim before the next edition, are to be issued as a subscribers' service

Dr. Paul Titus (Pittsburgh), of the American Board of Obstetrics and Gynecology will continue as the Directing Editor, and Dr J Stewart Rodman (Philadelphia), of the American Board of Surgery, continues as Associate Editor The Editorial Board will be composed, as before, of the Secretaries of the fifteen American Boards

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TRANSACTIONS OF THE SOUTHERN SURGICAL ASSOCIATION

MEETING HELD AT NEW ORLEANS, LA
DECEMBER 7-9, 1943

ADDRESS OF THE PRESIDENT PSYCHOSOMATIC SURGERY[†]

BARNEY BROOKS, M D
NASHVILLE, TENN

FROM THE DEPARTMENT OF SURGERY VANDERBILT UNIVERSITY SCHOOL OF MEDICINE, NASHVILLE, TENN

"THE OPERATION" is and will no doubt continue to be the dominant feature of surgery. In the anticipation of an operation a patient presumably has fear and dread. An operation often produces such an impression on a patient's memory that he may for the remainder of his life refer to past events as happening before or after "my operation."

The surgeon of today, as of yesterday, must of necessity be a man endowed with the sort of mind suitable for making quick decisions and proceeding with a minimum amount of delay in bringing to a conclusion a task with which he is often unexpectedly confronted. Many of his problems are of a nature which does not permit leisurely reflection. If a patient is admitted to the hospital with an acute attack of intra-abdominal disease, a decision must be reached quickly as to whether the patient is to be submitted to operation or not, and often in deciding to delay operation, the surgeon must assume an even greater personal responsibility for the preservation of the life of his patient. In the operating room, whether it be the head, chest or abdomen which is open, the surgeon is confronted with the necessity of bringing the operation to a successful or unsuccessful conclusion in a limited space of time, but no matter how objective the mind of a surgeon, I imagine

[†] Address delivered before the Southern Surgical Association, December 7-9, 1943, New Orleans, La

there is none who has become so calloused that his heart does not beat faster before beginning a formidable surgical operation, or during the course of an operation when it is noted that the patient's breathing becomes shallow, the arteries spurt with less vigor and the veins become distended with dark blood.

The well known scene in the operating room has not greatly changed since the last generation. There is much the same operating team, gowned and masked and gloved. There have been no significant changes in the tools which the surgeon employs. There is the same prostrate patient, of whom Doctor Halsted spoke as an individual left with but a single weapon, his spurting artery, to resist the continued application of the therapeutic procedure. I am sure that no surgeon of today privileged to witness the manual dexterity in anatomical dissection of the masters of surgery of past generations would for a moment entertain the idea that this feature of "the operation" has improved.

Although the scene in the operating room remains much the same today as it was 25 years ago, new methods to be employed before and after the operation have made it possible not only to perform the surgical operation with far less risk, but have extended the usefulness of operative surgery for the relief of conditions previously unknown or believed to be irremediable. It is the purpose of this paper to inquire into the effect of this advance in knowledge in surgery in the realization of the fundamental purposes of surgery, that is, the prolongation of life, the removal of disabilities and the relief from an unfavorable balance in the pain-pleasure principle in those individuals receiving surgical treatment.

In the beginning surgery was objective, anatomical and for the most part destructive. Most of the operations were amputations, ligation of arteries or excision of tumors. Surgeons received their preliminary training in anatomical laboratories. The immediate result of the discovery of methods of anesthesia and asepsis was only to increase the number and scope of operations based on factors almost purely anatomical. I remember less than 25 years ago, after I had completed a gastrojejunostomy, the referring physician remarked that it was indeed a strange sort of an operation because nothing was removed. I can recall, also, when I was given the responsibility of establishing a surgical pathology laboratory for the Washington University Medical School in 1912, the very large number of normal uteri, small cystic ovaries, acutely inflamed fallopian tubes, kinked appendices and tuberculous lymph nodes brought to me for pathologic examination.

The introduction of the use of the roentgen ray served at first almost entirely to enlarge the opportunities for the determination of anatomic abnormalities. The preponderance of a materialistic philosophy in surgery is illustrated by the frequency with which surgical operations were performed for the replacement of such structures as the stomach and large bowel, which from roentgenologic examination had been presumed to be dislocated. Also, the introduction of the use of the roentgen ray in the treatment of fractures not infrequently led to a state of mind which is well illustrated by a personal

experience An orthopedic surgeon asked me if I would come to a Roentgenologic Department so that I might see the good results he had obtained from a series of fractures of the leg I am quite sure that he did not understand me when I told him that I would much rather see his patients walk, and it has often occurred to me since to wonder if the treatment of fractures of the leg were not more successful when it was the purpose of surgeons to make the external appearance of the fractured leg correspond as nearly as possible to that of the unfractured leg, than at the present time when surgeons attempt to secure perfect anatomic restoration of the bone fragments by the use of one or more of the several mechanical appliances which sometimes remind me of an exhibit which I once saw of the instruments used for torture at the time of the Spanish Inquisition

During the past 25 years, and particularly during the past ten years, there has been a tremendous advancement in knowledge applicable to surgery which can perhaps best be said to belong to physiology It is much to the credit of surgery that a great deal of this valuable knowledge has been the result of the laboratory experiments of a group of surgeons now arrived at their maturity, and who, I am glad to say, have been more than welcomely received by the older group of surgeons who did not have the good fortune of the opportunity and the stimulus for laboratory investigation

Following the development of knowledge of the physics and the chemistry of respiration, there was almost immediately a tremendous advance in surgery of the chest I believe I am not making any overstatement when I say that the low operative mortality and the smooth postoperative course of a patient after a pneumonectomy still seems almost miraculous to those of us who began the practice of surgery as long as 25 years ago Recent developments in the knowledge of the physics and chemistry of the body fluids not only have reduced greatly the risk of old operations, but have made it possible to undertake with safety operations previously considered to be associated with a prohibitive operative risk The beneficial effects of surgery have thus been extended to a large group of people previously considered inoperable The significance of this achievement becomes greater when it is realized that our population is growing older and that individuals are not so frequently "too old" to be operated upon

It is worth while calling attention to the fact that although surgeons have become physiologists as well as anatomists, the essential philosophy of the surgeon is still for the most part materialistic Water, sugar, sodium chloride, proteins, carbon dioxide and even hydrogen ion concentration are just as real as muscle or tendon or nerve There is, however, a fundamental difference between the old anatomical surgeon and the modern physiological surgeon, in that the latter has opportunities for being what, for lack of a better term, we might call constructive An appendix can only be removed Sodium chloride may be either added or subtracted I believe that there can exist at the present time no reasonable doubt that the accomplishments of the surgeon have been vastly increased because of this knowledge of conditions in the human body not immediately discernible to any of the special senses

It remains, however, to call attention to the fact that a purely materialistic philosophy in surgery carries with it the necessity of a fundamental conception which I believe is apparent in nearly all of the innovations in surgery, as well as in the evaluation of the results of the numerous well established operative procedures. The surgeon with only a materialistic philosophy must conceive of each human being as compared to a standard human being, a sort of John Doe. During the early anatomical phase of surgery, Mr. X, who differed from John Doe, had only the possibility of surgery making him into a conventional part of John Doe. The addition of the physiologic concept into surgery brought with it the idea that certain departures of a Mr. X from John Doe might be restored or compensated for, in order to improve Mr. X's well being, or, more frequently, to improve Mr. X's chances of survival of some major anatomic alteration.

I have had the good fortune to observe a considerable succession of men through periods of five years of postgraduate training in surgery, and I am quite sure that I am correct in stating that almost all the effort of the Resident Surgeon today is directed toward the accumulation of facts concerning abnormalities of anatomy and physiology of the patients for whom he is trusted to assume great responsibility. No other than the most arrogant and selfish Chief Surgeon would fail to recognize the enormous amount of comfort he derives from the knowledge that an efficient Resident Surgeon with only a materialistic philosophy is in constant attendance on the surgical wards, not to mention the number of times success has been obtained or even a catastrophe has been averted in the Chief's own cases by prompt action or timely suggestion of the realistic resident.

It is worth while pointing out, however, that nearly all of the new methods of obtaining a better knowledge of abnormalities of anatomy and physiology are, so to speak, impersonal. In fact it is entirely possible, if not commendable, for one at the present time to arrive at an accurate estimate of certain surgical diseases and apply suitable operative treatment without making use of any information conventionally known as the history and physical examination. There is, therefore, often a great expenditure of effort on the part of the young surgeon in training to collect information concerning conditions identical with or different from the standard John Doe without any attempt to get acquainted with John Thompson, III, Michael O'Flaherty, Johann von Ribbentrop, Vittoria Angelucci or Abie Cohen, not to mention the patient being just one individual of one of these groups.

During the days of diagnosis by history and physical examination alone, there was certainly a great deal more opportunity for the young surgeon to find out something about the patient's social position, ambitions, anxieties and other intangibles which, after all, are the only determinant of an individual, and, perhaps even more important, for the patient by revealing his intimate personal attributes to obtain a conviction of confidence in the surgeon, which not only insures a diminished risk of operation, but which, if enduring, contributes greatly to the patient's ultimate restoration to health and happiness.

This matter of a surgeon's obtaining a conviction of confidence in him on the part of the patient is of much more importance than the attention it has received. In fact, I believe I am correct in saying it has been more often discouraged than encouraged. I am quite sure the "success" apparently obtained on the basis of personality rather than ability has been too frequently the subject of ridicule. Inability on the part of an able young surgeon to acquire patients not only contributes to the period of time which he has to wait before beginning to make his contribution to the world, but what is more pathetic than a well trained surgeon without anything to do? The fact that some practitioners of surgery obtain a large clientele by pomposity, the wearing of loud clothes, or advertising just within the rim of acceptable ethics, should encourage rather than discourage the stimulation of well trained young surgeons to acquire an understanding of the psychology of transference.

This brings us directly to the consideration of another special field of interest in medicine—psychiatry—of which I can make no claim of possessing any more knowledge than would be acquired from reading and from 30 years of experience in the practice of surgery in a clinic, the primary purpose of which is undergraduate teaching of medicine and postgraduate training in surgery. This experience has afforded me an excellent opportunity of realizing the close personal relationship which exists between the surgeon and his patient in a large variety of individuals. In this experience I have also been able to enjoy a very close personal relationship with a considerable number of surgeons in the various stages of their development. Each succeeding year I am more impressed with the large number of physical and chemical tests with which the resident surgeon must be familiar, and, I may add, must be able to interpret to his Chief, so that I can condone rather than condemn his viewing an individual patient only from the viewpoint of a mechanism gone wrong. I know that age and experience will so alter his methods of the practice of surgery so that, although he may not admit it, he will subsequently include in his consideration of a sick man many intangibles not revealed in physical and laboratory diagnostic procedures.

My personal relationship to psychiatry has been very well expressed by Dr. Louis Hamman in a paper delivered before the American Association for the Advancement of Science, of which the following is a quotation:

"When I was a medical student, psychoneurotics were objects of ridicule and contumely, not of serious study and sympathy. The patient with no gross lesion to justify his many complaints was neglected and avoided. The worst insult that could be cast at a fellow student was to call him a neurasthenic. After careful observation had established the fact that a patient had no organic disease, professional relations were supposed to be at an end, and he was dismissed with some such reassuring remark as, 'There is nothing whatsoever wrong with you. Your troubles are imaginary. Go on and forget them,' or even more curtly with a placebo and the ardent hope that he would never return.

"With the passage of years this brusque attitude has become somewhat

softened and yet essentially it is still the attitude of many physicians. The mind always seeks precise classification and is never more pleased than when experience can be snugly labeled. Packing it away in this neat fashion is so much more satisfactory than delving about for explanations that require long and painstaking investigation and may in the end elude our search. The great number of elaborate tests now available for diagnosis plays smoothly into this indolent habit of mind. Surely one of them will sooner or later reveal some abnormality, and upon this slender thread of evidence the patient's symptoms conveniently may be strung."

From a present day evaluation of the methods employed by all practitioners of medicine before a comparatively recent period, one is forced to conclude that physicians must have attained recognition for rendering useful service because of their abilities to alleviate human suffering by psychotherapy rather than because of specific materialistic therapy. It is interesting to point out that it is possible that the violence of the therapeutic methods employed by eminent practitioners of the past, such as bloodletting and purgation, were after all the means by which a psychotherapeutic result was obtained. Without any thought of commending the use of the surgical operation as a psychotherapeutic method, it is well for the surgeon to bear in mind that the operation may produce an effect beyond a mere alteration in anatomy or mechanistic physiology.

When psychiatry was recognized as a special field of medicine, the pure psychiatrist was for the most part concerned with the major psychoses, which, after all, were only labeled by the application of descriptive names, and the sufferers were committed to institutions of unbelievably inhuman environment. Psychiatry retained a slender connection with objective medicine through the frequency of its combination in practice with organic neurology, which latter interest has at present almost completely passed into the hands of the neurologic surgeon. The utter pity and loathing of all men for the insane lives today in the almost universal prejudice which even men of medicine hold for a psychiatric consultation, just as the fear and dread of a surgical operation, because of the horrible years before anesthesia and antiseptics, has but recently been greatly reduced.

Even if I were competent to do so, it would take us too far afield to attempt a résumé of the history of psychiatry. It is not necessary for one to do more than attempt to read but a relatively small part of psychiatric literature to find out that a large number of so-called psychiatrists are unable to write papers or books in language which is intelligible, even if the reader makes full use of the most comprehensive dictionary. A recent editorial in the *American Medical Journal* cites a specific example.

From the psychiatric literature which is intelligible, it is clear that the differences in viewpoint of psychiatrists are such that there is even mistrust in each other. There are the psychiatrists who apparently have completely abandoned all consideration of the somatic aspects of disease, except for a sort of a vague retention of a concept of the frontal cerebral lobes. This group

accepts the psychology which William Morton Wheeler compares to an anatomy based purely on observations of the more aesthetic aspects of the head and upper extremities. Some psychiatrists prefer to consider the penis as the root of all evil. And here it is a case of apparent identity of *have* and *have not*. The psychoneuroses of the male start at the time of discovery of the organ, and those in the female with the discovery of its absence. This school of psychiatry by accepting the existence of an influential unconscious mind, is based on a more realistic and understandable psychology which is consistent with the generally accepted principles of evolution in biology. Unfortunately, this school of psychiatry has been hampered in its development by some of its followers placing too much emphasis on sex and assigning too great a value to psychoanalysis as a therapeutic method. There is a universal prejudice against personal revelation of matters of sex, and it has not been proven that the elevation of components of the unconscious into the conscious mind by the long and tedious process of psychoanalysis is the most important method of dispelling the manifestations of a psychoneurosis. However unpleasant the ideas of the psychoanalysts may be, they have undoubtedly made a great contribution to psychiatry, and this contribution will increase as other components of the unconscious mind are given more consideration.

Some psychiatrists are apparently interested in demonstrating that psychic abnormalities are the primary etiologic factor in the production of organic disease, as, for example, duodenal ulcer. From this group come reports of miraculous cures, usually of a single case, and often seemingly for the purpose of revealing the incompetence of the practitioners of surgery. The following is an extreme example based on "hearsay" evidence, but if every word were true, it is still without value.

"A very famous surgeon sent a young woman who was suffering with toxic thyroid to him with the request that he get rid of some of her fears so she could be operated upon, her pulse being so rapid that surgery could not be considered. The psychiatrist analyzed the girl and at the end of three months sent her back to the surgeon minus fears and minus her goiter. The famous surgeon bewailed the loss of his patient, but expressed happiness over the outcome of the case."

Although there still remains a large amount of distrust of psychiatrists in the minds of the objective practitioners of internal medicine, and the even more objective practitioners of surgery, there is certainly developing a better sort of psychiatry, and, even more important, there will almost certainly come out of the experiences of the present war a better understanding of the psychic aspects of disease. Even a casual examination of the reports of the battle casualties in the various military hospitals is convincing evidence that in spite of the presumable rejection for active military service of all men with existing psychoneuroses, many are accepted without adequate reserve of emotional control to withstand the stress and strain of actual warfare.

Primarily because of my feeling that succeeding groups of young men for whom I was assuming the responsibility for their surgical training were

having to acquire such an ever increasing amount and complexity of objective information concerning surgical patients that there was little time or incentive for understanding or appreciating an individual as something more than a machine gone wrong, we undertook what appeared to some of my associates the dangerous experiment of bringing a psychiatrist and psychologist into the surgical wards. This experiment was made possible by the cooperation of Dr. Frank Luton, head of the psychiatric division of the Department of Medicine, Vanderbilt University Medical School, the generosity of the Rockefeller Foundation, and the good fortune of securing the services of Dr. Smiley Blanton, an experienced psychiatrist, and Miss Virginia Kirk, a well trained psychologist of large medical experience.

It also occurred to me that such a project might contribute to the development of psychiatry as well as giving a broader viewpoint to the young surgeon in training.

I believe the experience of the psychiatrist, at least for the most part, is limited to his dealing with individuals in whom apathy, anxiety, or fear is present to a degree quite without the limits of that which can occur in what, for lack of a better term, one must call the average individual. Furthermore, he is deprived of the opportunity of subjecting individuals with whom he comes in contact to conditions peculiarly effective in producing major emotional responses. He sees mental disease only in its later stages, and perhaps only in individuals who have always been without the range of the normal in emotional responses.

The surgical wards offer daily instances of various degrees of anxiety in individuals, male and female, of all ages and states of emotional stability. Furthermore, the exact time at which a major stimulus arousing anxiety is to be applied is often definitely known, and in many instances could be chosen to suit the problem being investigated.

A study of conditions before and after operation by methods known only to the experienced psychologist would undoubtedly advance our knowledge of both psychiatry and surgery. Before operation there would be the patient whose symptoms of a surgical disease were in reality a psychoneurosis, and the patient with anxiety associated with an organic surgical disease or its treatment. After operation there would be the patient restored to full health, some who had but a few months to live, and perhaps an even more important group, those who have to wait some years for the possible or probable recurrence of a malignant disease.

There is always the difference of opinion as to whether the patient with an incurable disease should be told the truth or a falsehood, and if he is told the truth, shall it be done by gradually working up to the bad news, or should he have the worst news first and subsequently be given every encouragement which it is reasonably possible to give? Then, too, there are the two patients who are to have the same operation the same morning—one dreads “going to sleep” and the other cannot bear the idea of being conscious while “under the knife.” In fact, the greatest difficulty encountered in this project was to keep

from spreading too thin over the large number of interesting problems of which we were immediately aware

It is not the purpose of this paper, nor has the investigation reached such a stage, to give a detailed report at this time, but there has already been some evidence of real accomplishment

First of all I wish to stress particularly the reaction of the ward patients to submitting themselves to psychiatric investigation. Almost all of the ward patients came directly or only slightly indirectly from the farms in the vicinity of Nashville. There have been no difficulties because of different languages. They come from a people emotionally as well as geographically stable. During the past year all of the ward patients of surgery have been at least exposed to a psychiatrist, and 64 patients have had a complete psychologic study except for psychoanalysis. Only two patients have not been agreeably cooperative. During the same period on the private pavilion there has been universal objection, and in most cases positive refusal to accept a specific request for psychiatric consultation. The explanation for this difference lies in the fact that the psychiatrists were not labeled on the wards—they were not only permitted, but encouraged to pose as members of the surgical staff.

The frequency of the occurrence of the modification of behavior because of anxiety arising from other sources than the surgical organic diseases and their surgical treatment is illustrated by the results of the psychiatric examination of 14 consecutive cases of acute appendicitis operated upon and found to have definite acute inflammatory process in the appendix. Seven of these cases were found to have evidences of anxiety of sufficient gravity to be of clinical significance. In two cases operated upon during the same period in which no organic change was found in the appendix, psychiatric examination disclosed sufficient evidence to justify the conclusion that the symptoms and signs of acute appendicitis which were such that operation was indicated, were in reality manifestations of neuroses.

The patient with symptoms and signs of acute appendicitis sufficiently characteristic to make delay of operation dangerous, and subsequently at operation found to have no demonstrable pathologic change, constitutes a problem to which surgeons have not devoted the attention deserved. The importance of considering the psychic aspects of malignant tumors, disabling deformity, or unsightly disfigurement is such that preoperative preparation of the patient for these results is just as important as is the transfusion of blood or compensation for vitamin deficiency to reduce the risk of operation and promote the healing process in the operation wound.

It has been of particular interest to find out that only a small proportion of patients manifest any signs of great fear or dread of an impending operation. In reality, more frequently patients have exhibited evidence of relief from anxiety because of the anticipation of being so positively and perhaps so quickly cured by a method which may appeal to them also as an atonement for their past and secret sins. This suggests that the psychoneurotic patient who makes much of her previous operation has not in reality been made a psychoneurotic

because of this operation, but that she is merely utilizing this experience as an integral part of her neurotic pattern. It is also not impossible that the patient who states she has been in absolutely perfect health since a cholecystectomy—with the removal of a perfectly normal gallbladder—is contemplating the operation from the crest of a wave of a mild manic-depressive insanity. Recently a patient upon whom I performed a radical removal of the rectum made a trip from a distant city in order that she might let me know from her own lips what a wonderful asset she had in her permanent colostomy. After listening to her for an hour I decided henceforth I would specialize in the performance of colostomies only in individuals with manic-depressive insanity who were about to emerge into the stage of elation.

I confess that I find it difficult to make definite statements of the reaction of the visiting staff, house staff, and undergraduate students to the inclusion of a modicum of psychiatry in the department of surgery. The visiting staff at least have ceased to make any objections, and on a few occasions I have noted at least a glimmer of interest. The house staff have at least been aware of my own interest in a project, the purpose of which is to shorten the time in which they will acquire that indescribable something frequently referred to as "surgical judgment" and heretofore presumably acquired only by long experience. After all, in this matter it is the state of mind which is important. There is certainly no thought of making even one of my surgical house staff into a psychiatrist, but I cannot but believe that they will be better surgeons for having been stimulated to discover before roentgenologic examination that a man complaining of abdominal discomfort, loss of appetite, weight and strength may have these symptoms because his only son is in the Solomon Islands. The subsequent diagnostic tests may then be conducted with more sympathy and the final diagnosis made and the treatment given with a better prospect of success because of this better understanding. God forbid that the roentgenologic examination should ever be omitted.

All of the undergraduate students assigned to the surgical wards attend a discussion of current problems, led by the psychiatrist, once each week. Their interest is demonstrated by the librarian's finding it necessary to place on the reserve shelf several of the recent books on psychosomatic medicine, which, incidentally, has caused me considerable inconvenience in the preparation of this paper.

Analogous to Mark Twain's often repeated observation concerning the weather, practitioners of objective medicine have been content with calling attention to the fact that the many schools of medical quackery exist solely because reputable physicians and surgeons ignore not only psychic abnormalities, but also the psychic aspects of organic disease. The neurotic patient turns to the quack for help when told there is nothing the matter with him, and not infrequently the patient with incurable organic disease makes use of this last ray of hope with at least the quasi approval of the surgeon. The solution of the problem of quackery will not come from the efforts of organized medicine to abolish it by legislation as surely as it will follow the introduction of a

better psychiatry into surgery and perhaps a little bit more knowledge of organic medicine into psychiatry

If one wishes to pursue this ideology further in an imaginary world to a complete surgical Utopia, particularly if he were one who has the responsibility to choose as well as to train surgeons, some of whom he hoped would some time attain the distinction of membership in this Society, he would also at least give some thought to the psychic as well as the somatic aspects of the individual selected. I am quite sure that many of you have known men adequately equipped with knowledge and manual dexterity who, in spite of years of effort, have not attained success as surgeons. Even the best surgeons, I feel sure, have some off days, and at times feel that they have committed sins of omission or commission because of a diminished reserve of emotional control. A good surgeon, therefore, must have not only a sound body, but an adequate control of will to maintain a calm and clear mind under conditions of stress and strain which at times may even be too much for his assistants. At considerable personal inconvenience I maintain my office in the Vanderbilt University Hospital immediately adjacent to the operating rooms for the sole reason of having my house staff feel that immediate aid is available if unexpected difficulties are encountered, and I am quite sure I have thus given courage a good many times to conscientious young surgeons to bring to a successful conclusion operative procedures which otherwise would not have been undertaken. Occasionally I have purposely refrained from helping a young man with a good mind and nimble hands to obtain opportunities for surgical training because I believed he was not emotionally constituted for becoming an accomplished surgeon. It is at least not too much to hope that out of the vast experience which is now being obtained from the application of psychological tests for the selection of men for a great variety of special tasks, something may be developed which will be helpful to the young man in determining his fitness for the widely different fields of medicine, before he may have spent the best years of his life preparing for a profession in which he cannot attain the success for which he has hoped and for which he has labored so long.

SYMPOSIUM ON ABDOMINAL SURGERY

INDICATIONS FOR, AND EXPERIENCES WITH, TOTAL GASTRECTOMY*

BASED UPON SEVENTY-THREE CASES OF TOTAL GASTRECTOMY

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IN 1938, eight cases of total gastrectomy were reported from the Lahey Clinic by one of us (F H L),¹ with three postoperative deaths. Since then, 65 additional patients have been submitted to total gastrectomy, with 21 deaths. Of the entire group of 73 patients, there were 24 postoperative deaths, an operative mortality of 33 per cent. During the last two years, total gastrectomy was performed upon 28 patients, with five postoperative deaths (18 per cent), a notable reduction in operative mortality.

Total gastrectomy has opened up a relatively new field in the treatment of gastric malignancy and has now become an accepted surgical procedure, with a reasonable mortality.

We have always felt that when we had had a sufficiently large experience with total gastrectomy, we should review our records and decide whether, in advising this procedure, we could assure patients a reasonable prospect of life and relief of symptoms. It, therefore, now seems important to present our experiences in terms of whether the patient's existence is satisfactory after a total gastrectomy, how long it prolongs life, and the prospects of cure in the lesser grades of malignancy, such as lymphosarcoma and leiomyosarcoma. It also seems desirable to present our accumulated data and convictions concerning the preoperative selection and preparation of patients, method of approach, types of anesthesia, operability, technical considerations, results and postoperative feeding and diet.

SELECTION OF CASES AND METHOD OF APPROACH

The history of the patient with gastric carcinoma appears to offer nothing of value in determining which patients should be submitted to total gastrectomy. Obviously, exploration is not justified in a patient who has a fixed lesion demonstrable by roentgenologic examination and palpable in the epigastrium, with nodules palpable in the liver. Likewise, exploration is not justified in a patient with a Virchow's node or a rectal shelf.

However, those lesions with rigidity of the entire stomach without obstruction, Virchow's nodes, a rectal shelf, fixation of the lesion, metastatic nodules palpable in the liver, or roentgenologic evidence of involvement of other areas, such as the transverse colon or the loops of small intestine,

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should be explored, even if the roentgenogram shows the stomach to be entirely involved by the lesion. The roentgenogram, therefore, is of great value in determining whether the patient may possibly be submitted to total gastrectomy.

We repeatedly have said that there are two distinct types of carcinoma of the stomach. The localized type, which so often proves inoperable, is frequently on the lesser or greater curvature and rapidly metastasizes to the adjacent lymph nodes. In the other type, the linitis plastica or leather bottle stomach type (Fig 1), the carcinomatous infiltration is intramural



FIG 1.—Linitis plastica. Roentgenogram showing complete involvement of the stomach by carcinoma.

and spreads through the walls of the stomach (Fig 2), streaming down between the muscle bundles in the gastric wall. This is the type of carcinoma that lends itself so frequently to total gastrectomy (Fig 3). We have often been surprised and have been unable to explain why such an extensive gastric carcinoma of the linitis plastica type can exist with little or no visible lymph node involvement when such rapid involvement occurs in the more localized and more common type of malignant lesion.

In addition to the linitis plastica type of carcinoma, lymphosarcoma with its tendency for mural infiltration (Fig 4) particularly lends itself to total gastrectomy. It produces gastric rigidity of a less striking character than does the linitis plastica type and is likewise without distant extension.



FIG 2—Photomicrograph of section of stomach showing carcinomatous infiltration of gastric wall in limitis plastica



FIG 3—Surgical specimen of limitis plastica type of carcinoma after total gastrectomy, splenectomy and omentumectomy

A third type of malignancy which lends itself favorably to total gastrectomy is the sarcomatous degeneration of multiple leiomyomas (Fig 5) In this condition the malignancy is of such low-grade character that total gastrectomy offers a real prospect of cure

A fourth lesion which lends itself favorably to total gastrectomy is carcinoma of the cardiac end of the stomach (Fig 6) In our group of 73 patients, several had lesions limited to the upper end of the stomach Previous to the employment of total gastrectomy, these patients were rejected as inoperable Among these cases are lesions extending up to, but not including,



FIG 4—Lymphosarcoma (a) Roentgenogram of stomach before operation showing extensive involvement with lymphosarcoma (b) Roentgenogram after total gastrectomy showing anastomosis of esophagus to jejunum Taken one year following operation Patient in excellent health Has gained 20 pounds in weight

the esophagus, and in addition to these and not included in this series, are cases of carcinoma of the stomach resected transpleurally

From our experience with the two procedures, total gastrectomy with anastomosis of the jejunum to the stump of the esophagus through the abdomen and transpleural resection by means of splitting the diaphragm and pulling the cardiac end of the stomach into the pleural cavity, we believe the former is safer, providing enough normal esophagus remains Those lesions of the cardia with enough esophagus for anastomosis are better approached through the abdomen with the prospect of employing total gastrectomy, than through the pleural cavity, for the following reasons With the abdominal approach, a thorough, satisfactory exploration for determination of operability can be performed under direct vision The pelvis can be examined for gravity metastases and implanted nodules low in the abdominal cavity and enteric lymph nodes can be felt In addition, removal of the entire omentum and spleen is possible, as well as safe and satisfactory mobilization and inversion of the duodenum These procedures



FIG 6.—Carcinoma of cardia. Roentgenogram showing carcinoma involving cardia of stomach. Patient alive and well four and a half years after total gastrectomy.

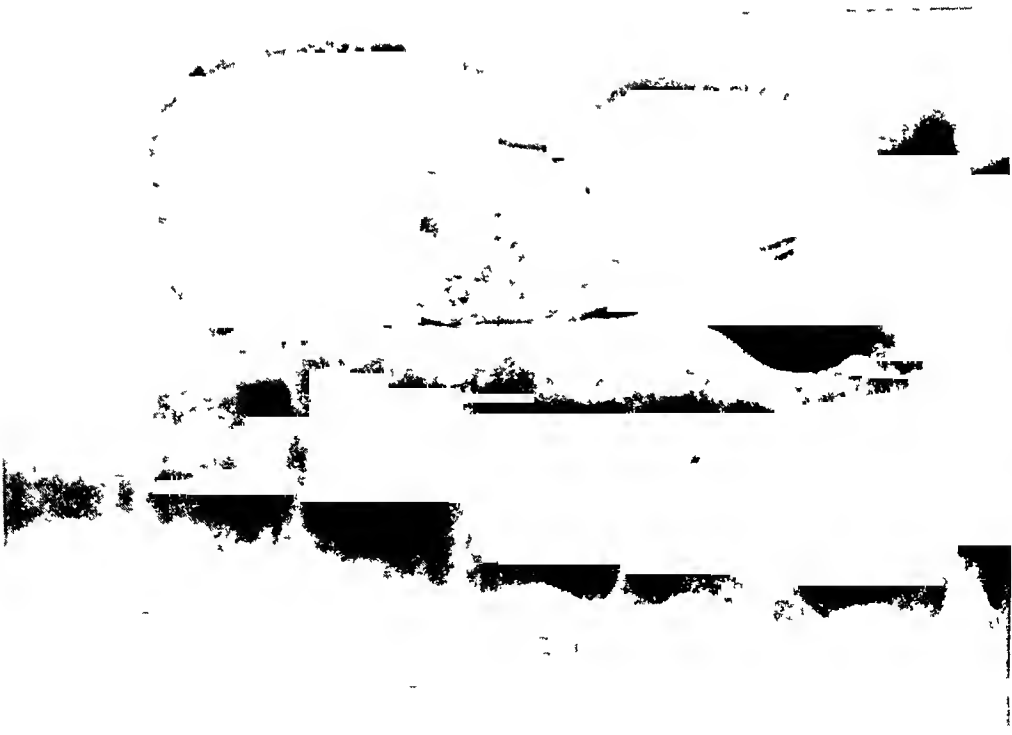


FIG 5.—Leiomyosarcoma. Stomach completely involved by large tumor mass of leiomyosarcoma. Patient alive and well six years following total gastrectomy.

TOTAL GASTRECTOMY

necessarily must be limited when the operation is performed transpleurally through the divided diaphragm. For these reasons, as already mentioned, we prefer the abdominal approach to lesions arising in the stomach when there is enough esophagus for anastomosis to the jejunum, and reserve transpleural resection largely for those lesions arising within the esophagus.

PREOPERATIVE PREPARATION

Many patients who must be submitted to total gastrectomy are elderly and invariably represent an increased risk group. They are often anemic and frequently are in a state of poor nutritional balance. The restoration of water and mineral balance is frequently necessary. Blood transfusions often must be given to restore hemoglobin and blood proteins to normal levels. Most of them should have glucose solutions intravenously for liver storage, and vitamin C in sufficient dosage.

For a number of years we have thoroughly lavaged the stomach of all patients with gastric carcinoma the evening and morning before the operation, using a dilute solution of hydrochloric acid (75 cc of concentrated hydrochloric acid in one liter of water). This procedure, which mechanically cleanses the stomach and cuts bacterial counts in the gastric contents down to a minimum, is of value in diminishing infection not only in total gastrectomy but in partial resection for carcinoma.

ANESTHESIA

Usually total gastrectomy can be performed in from one and a half to two hours, depending on the technical difficulties encountered. However, since the length of time necessary is largely unpredictable, all gastric resections, total and subtotal, in this Clinic are now done under fractional spinal anesthesia. By this method, small repeated doses of pontocaine can be given as often as necessary with certainty of complete relaxation during the most difficult technical portion of the procedure, that is, during anastomosis of the jejunum to the stump of the esophagus high up under the diaphragm. Although fractional spinal anesthesia has now been employed for several years with complete satisfaction in all our gastrectomies, we express the warning that it should be administered only by those trained and experienced in its use.

A part of the anesthetist's duty is the introduction of a Levine tube into the stomach. No gastric resection, either total or subtotal, is undertaken in this Clinic without the use of a Levine tube, by means of which it is possible to empty the stomach of gas or fluid. As the completely mobilized stomach is held up (Fig 11), any fluid within it tends to gravitate into the esophagus, from which it can be evacuated by means of suction applied to the indwelling Levine tube, and consequently it will not spill out into the peritoneal cavity when the esophagus is opened.

After the jejunum is tacked to the esophagus (Fig 13), the Levine

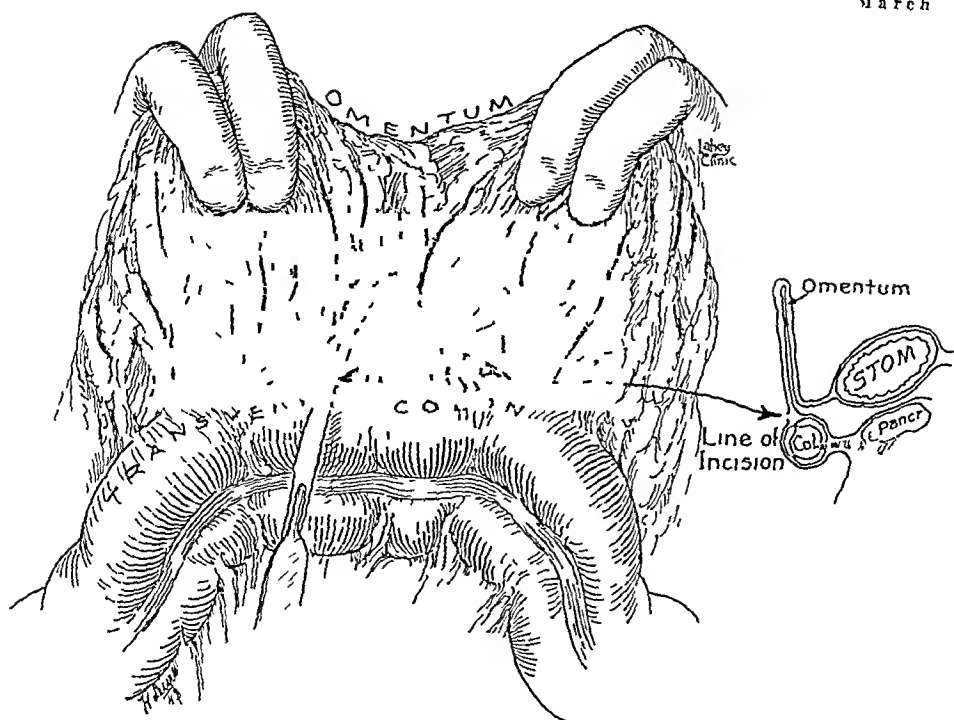


FIG 7—The first step in the separation is sharp dissection of the omentum from the transverse colon. Note the avascular line of cleavage. Note the developmental line of cleavage and the line of incision in the avascular area (insert)

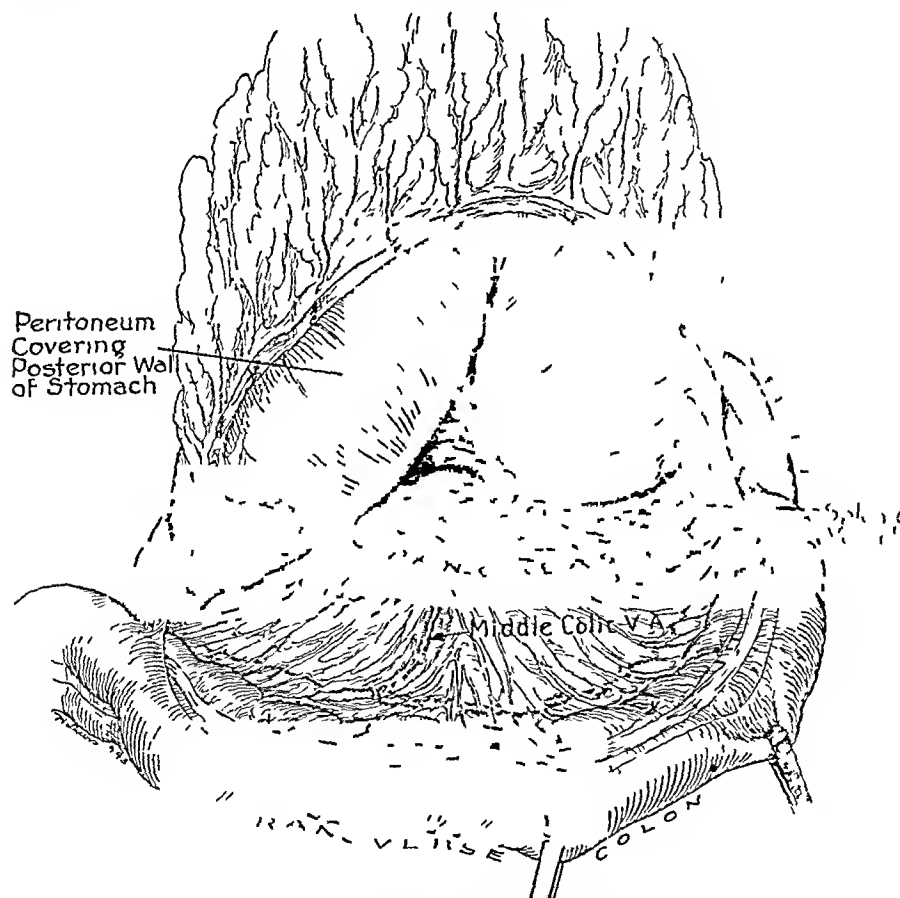


FIG 8—The omentum is completely separated from the transverse colon and is still attached to the greater curvature. The pancreas is visualized, and the stomach is turned up. Note the splenic vessels beyond the tip of the pancreas.

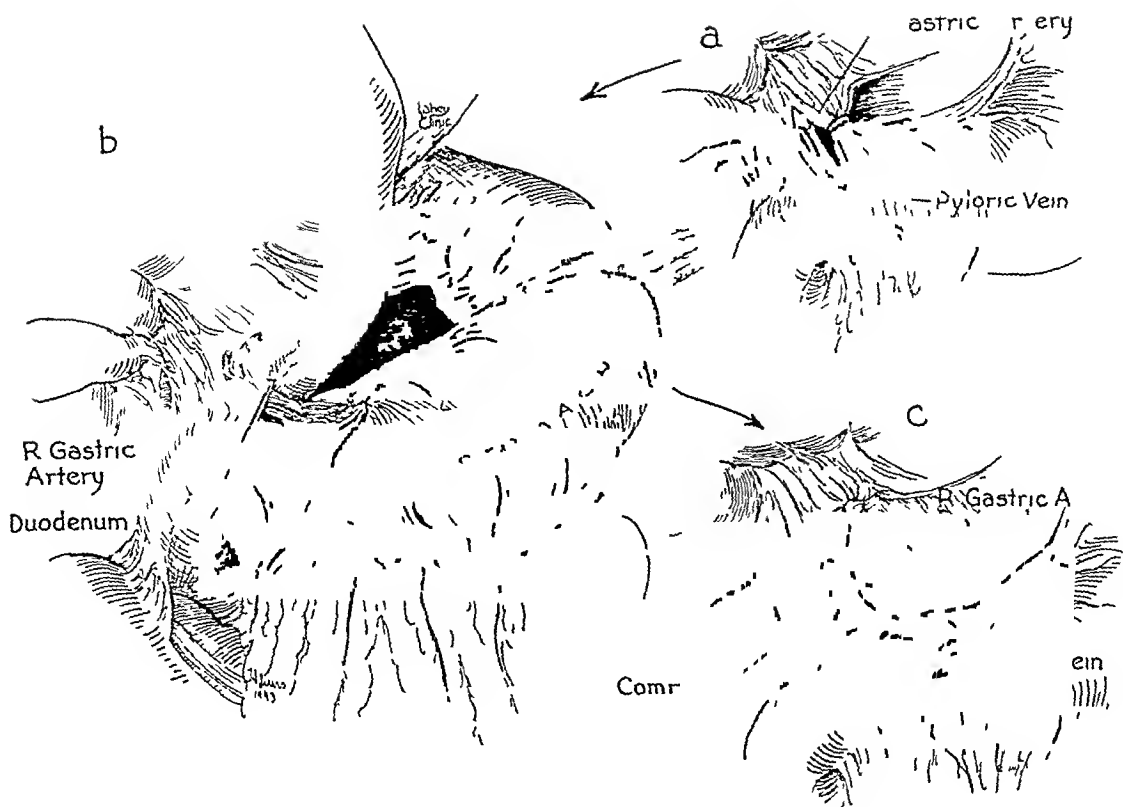


FIG 9—(a) The lesser peritoneal cavity is opened through the gastrohepatic omentum
 (b) The right gastric artery and vein are clamped close to the pylorus
 (c) Vessels of the gastrohepatic omentum have been ligated and the lesser curvature is cleared

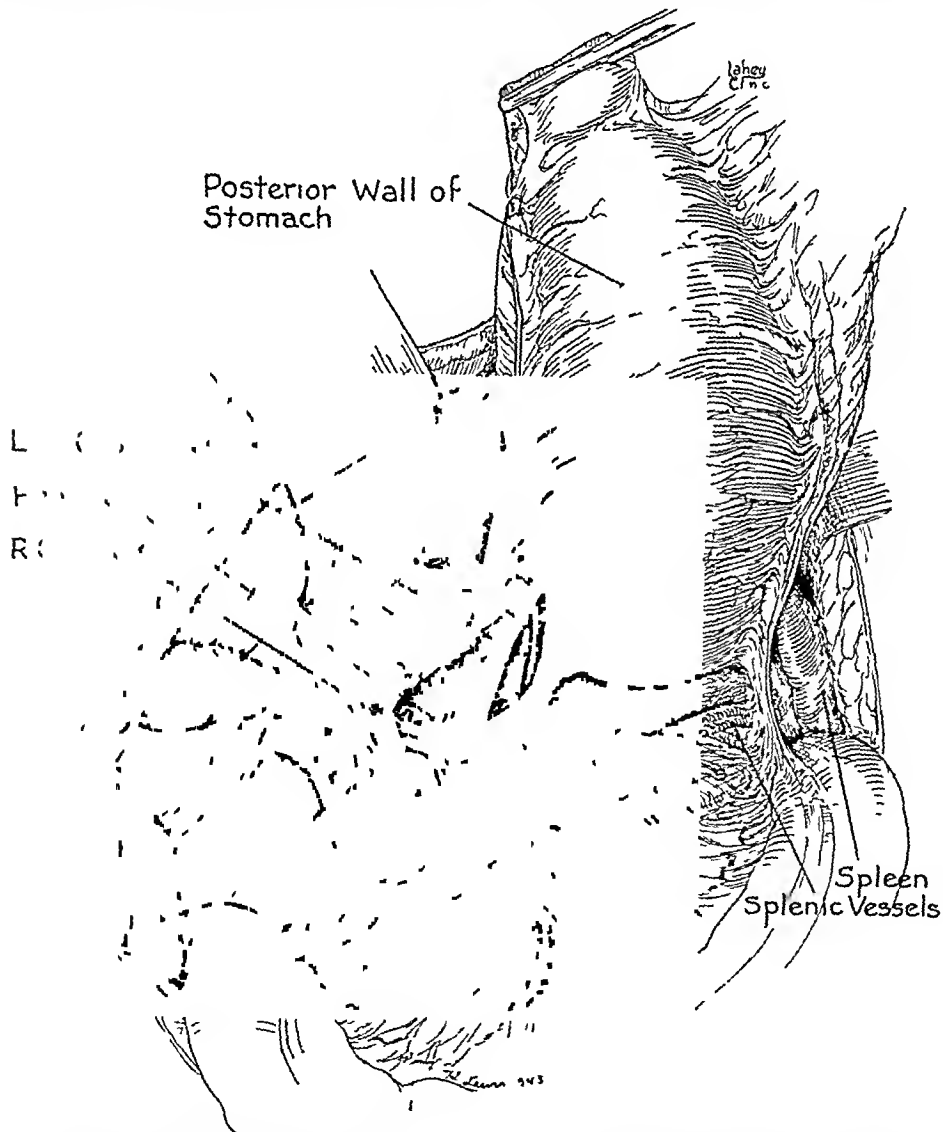


FIG 10—The duodenum has been cut across and inverted and the stomach has been lifted higher. Note the exposure of the left gastric vessels ready for ligation

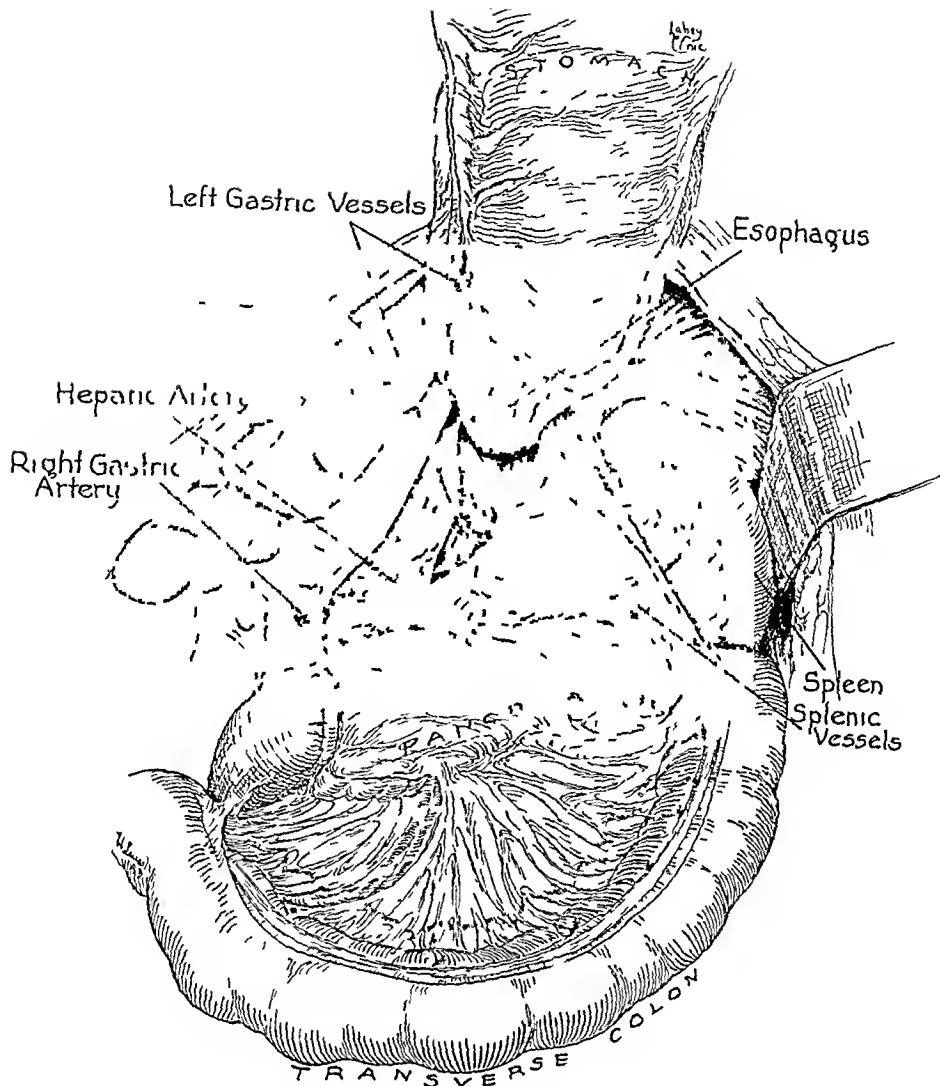


FIG. 11—The esophagus has been exposed and freed, the stomach has been turned up, and the pedicle of the spleen has been visualized. The left gastric vessels have been ligated. The spleen is ready to be removed with the stomach.

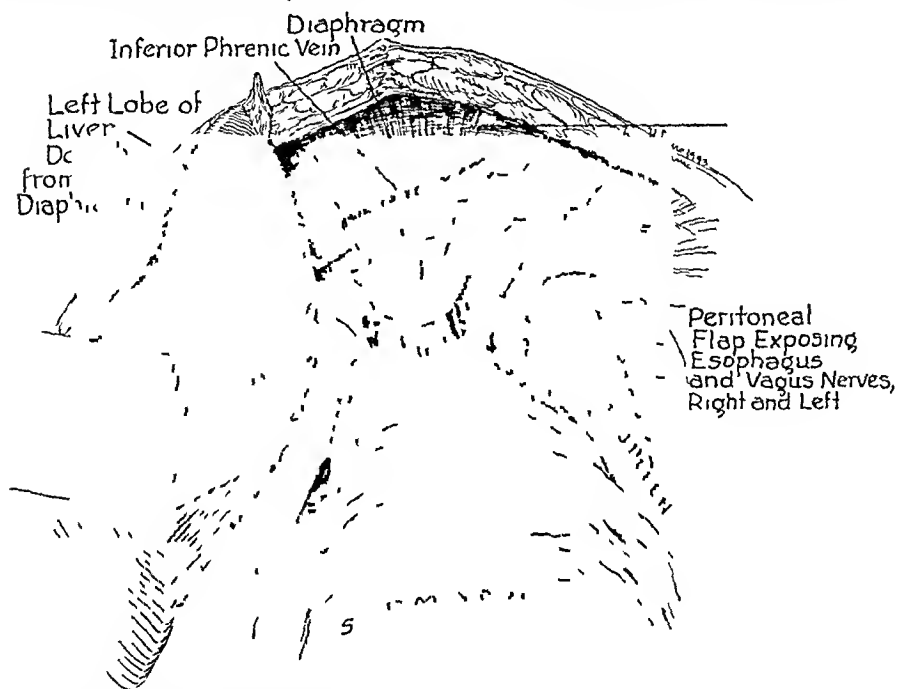


FIG. 12—The left lobe of the liver is mobilized to the right and the anterior flap of the peritoneum is reflected up over the esophagus. This is used later to suspend the jejunum in order to remove traction from the anastomotic line.

tube is withdrawn into the esophagus, thereby any accumulation of mucus within that structure can be withdrawn and prevented from passing out of the wound into the operative field. This procedure is extremely important in the prevention of soiling by leakage from the stomach or from the esophagus.

OPERABILITY

All cases considered for total gastrectomy are borderline in terms of operability, although in many cases the decision can be made before operation is undertaken. In others, exploration is justifiable, but the final decision of whether total gastrectomy should be undertaken must be made with the abdomen open. If the operation is to be logically applied, this decision must be extremely critical in character, since total gastrectomy with its relatively high mortality should not be undertaken when there is little prospect of greatly prolonging the patient's life or adding to his comfort. An unwise decision gives the operation a bad name, does not add luster to the reputation of surgery, and results in unnecessary expense and discomfort to the patient.

With increasing experience, we have become more expert in rejecting the hopeless cases. The surgeon should first explore the pelvis to eliminate gravity metastasis. If metastasis is present, regardless of how removable the lesion apparently is in terms of total gastrectomy, operation is, in our opinion, not justifiable. The transverse colon should be turned up and the jejunal fossa carefully investigated for firm nodes or direct extension of peritoneal implants. Since most gastric carcinomas which are favorable for total gastrectomy are of the linitis plastica type and are not ulcerative, firm nodes are generally assumed to be metastatic in character, and again in terms of total gastrectomy, the condition is inoperable. If on examination of the omentum, there are only a few firm nodes, the patient should not be rejected as a candidate for total gastrectomy, since the entire omentum with its nodes can safely be removed with the stomach. When, however, there is direct extension to the root of the mesentery of the transverse colon, the lesion is inoperable. Likewise, when there are peritoneal implants about the stomach, the lesion is inoperable. The surgeon should be particularly careful to palpate for a small nodular chain of lymph nodes which frequently run up through the diaphragm beside the esophagus. These are at times involved with a firm, continuous, shot-like chain of metastatic nodes, and although the lesion is removable, total gastrectomy is not justifiable. Obviously, investigation of the gastrophrenic omentum and liver would not be neglected. Not infrequently, the type of carcinoma one sees in linitis plastica produces thick, white infiltration along the greater curvature, particularly where the spleen is connected to it by the vasa brevia vessels. In these cases removal of the spleen (now routinely done in total gastrectomy) together with the stomach is desirable in order to get well outside the local extension of the malignancy. One of the most important decisions that must be made before attempting total gastrectomy is whether an adequate amount of esophagus remains uninvolved by the carcinoma for a satisfactory

anastomosis between the esophagus and the jejunum. Even with involvement of a small portion of the esophagus, as soon as the parietal and diaphragmatic peritoneum and the vagus nerves are cut, a considerable length of esophagus can still be pulled out of the pleural cavity for a safe and comfortable anastomosis.

TECHNICAL CONSIDERATIONS

Total gastrectomy has come into use so recently that every surgeon who performs the operation has gradually developed technical improvements which make it possible for him to undertake the procedure more expeditiously and more safely.

One of the most important technical features, in our experience, is the separation of the omentum from the transverse colon (Fig 7), opening the lesser peritoneal cavity, exposing the splenic vein and artery so that they readily can be ligated at the tail of the pancreas, so that the spleen can be turned up and removed with the stomach. Splenectomy, as proposed by one of us (F. H. L.), not only has not added to our mortality, but by improving exposure, may have diminished the number of deaths in the last few years when it has been an almost routine part of total gastrectomy. The omentum should be entirely freed from the transverse colon well over on the right side and separated well up to and including its attachments at the splenic flexure (Fig 8). After ligation of the splenic vessels, the mobilized spleen is attached to the stomach only by its vasa brevia vessels. With the stomach turned up, it is important to control the blood supply of the stomach from behind, with the lesser peritoneal cavity open and with the pancreas visualized (Fig 10). The left gastric artery can now be ligated high under direct vision, and all bleeding vessels on the lesser and greater curvatures of the duodenum can be controlled (Fig 9). The duodenum is clamped across and closed by open inversion with three rows of sutures, the last one being silk, and is then covered with the capsule of the pancreas. The omentum, spleen and stomach in one mass can now be wrapped up and tied in a large pad. The esophagus can be wiped free of the areolar tissue and pulled down as far as possible out of the chest. One of us in an earlier communication (F. H. L.)¹ suggested at this stage the detachment of an anterior and posterior peritoneal flap from that portion of the diaphragmatic peritoneum reflected over the esophagus (Fig 12), to be utilized later to suspend the jejunal anastomosis to the esophagus, thus taking dangerous traction off the line of anastomosis (Fig 15, c). This is extremely important because the esophagus is friable and at the best holds sutures poorly.

Anyone who has dealt much with total gastrectomy has been impressed with the fact that the vagus nerve on each side of the esophagus as it passes through the diaphragm greatly limits delivery of the esophagus. With the esophagus clearly exposed, both vagus nerves can be seen, and when severed immediately permit a surprising section of the esophagus to be pulled down from within the pleural cavity, thus bringing the esophagus closer to the

TOTAL GASTRECTOMY

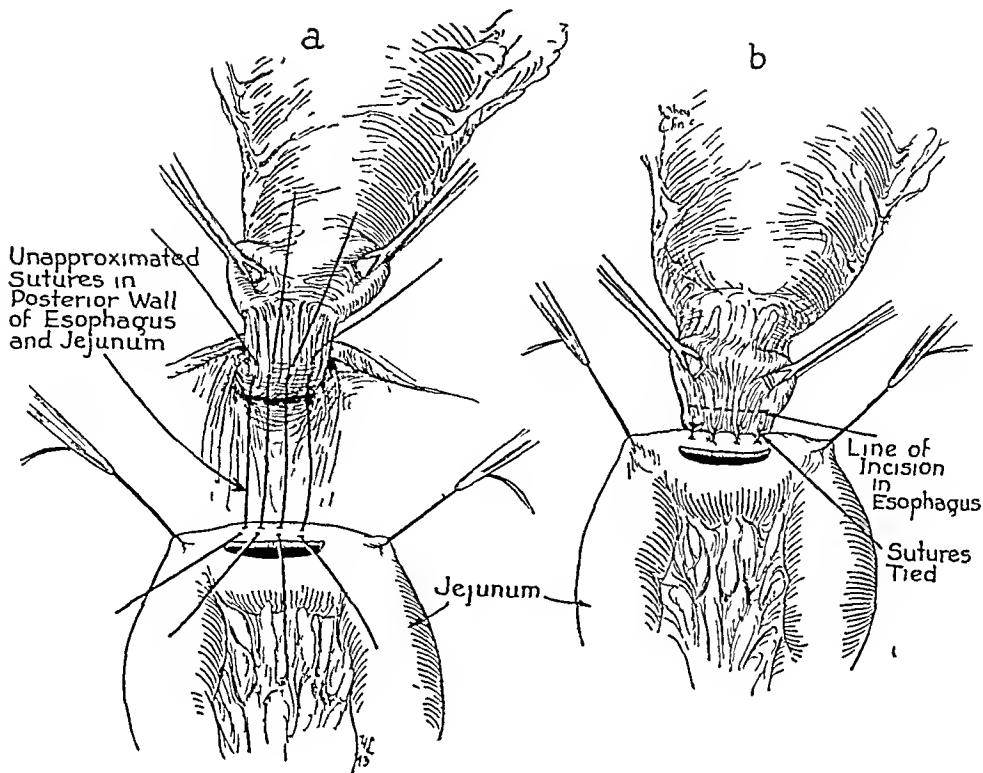


FIG 13 —(a) The preliminary introduction of a posterior row of untied silk sutures before opening the jejunum. Note the ease with which the jejunum may be opened and trimmed to fit the esophagus. (b) When the sutures are put in and tied before the jejunum is opened, satisfactory management as to size and fit of the jejunal opening is difficult with the jejunum pulled high up under the stomach.

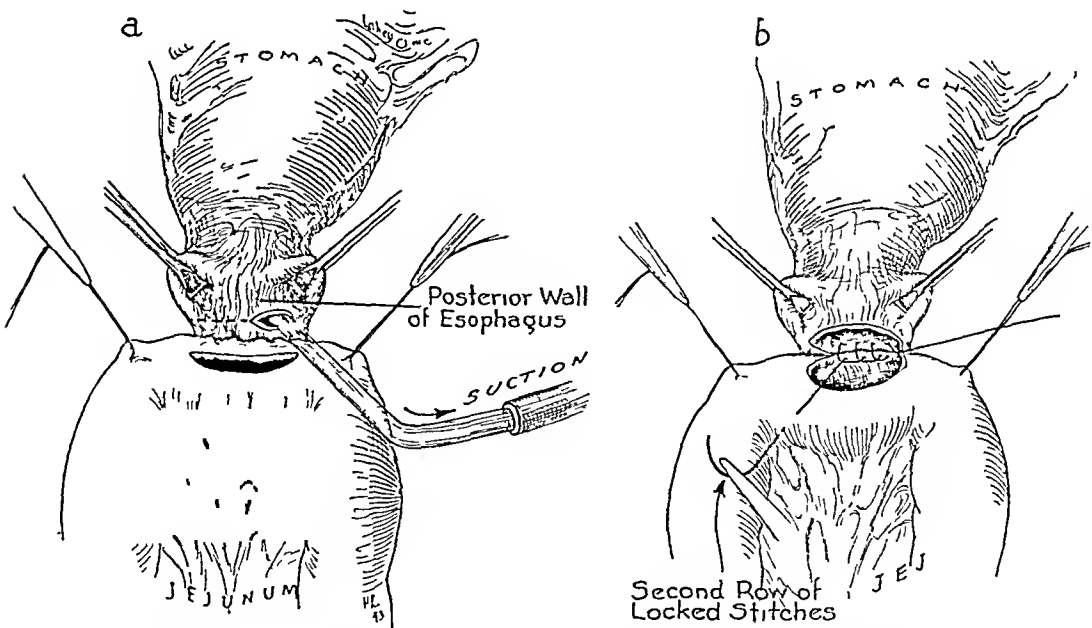


FIG 14 —(a) The traction stitches to hold the anastomotic opening are spread apart. The first row of silk stitches already has been tied. Note the small opening in the esophagus. (b) Note the locked stitches employed 1 step at a time as the opening gradually is increased in size until the entire posterior second row of stitches has been inserted.

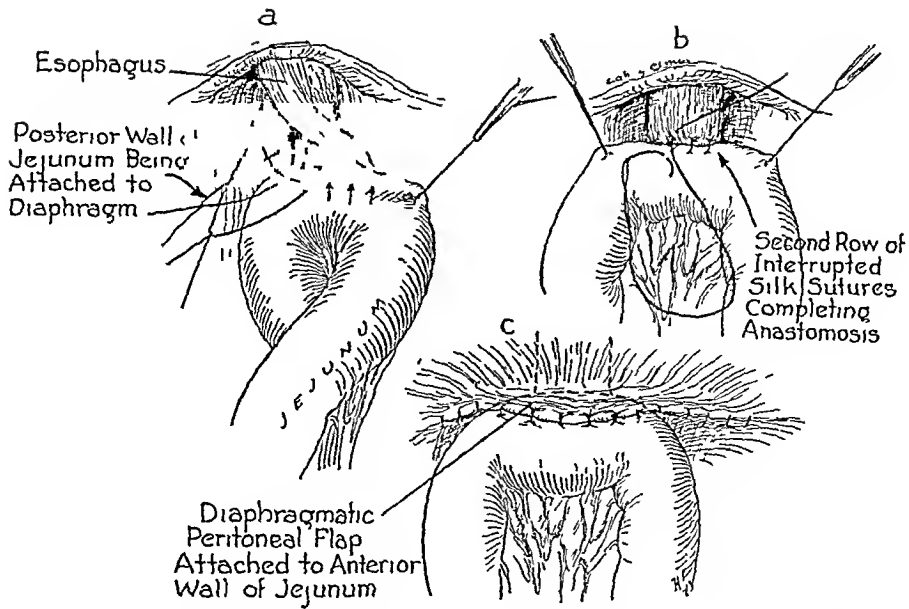


FIG 15—(a) The method of twisting the esophagojejunal anastomosis in order to inspect the posterior row of sutures, and the insertion of suspensory jejunal sutures posteriorly to take the strain off the posterior row of the anastomotic suture line (b) The application of the anterior second row of silk approximation sutures (c) The previously fashioned flap of diaphragmatic peritoneum sutured to the jejunum over the anastomosis to reinforce it, to suspend the jejunum and to relieve traction on the anastomotic line

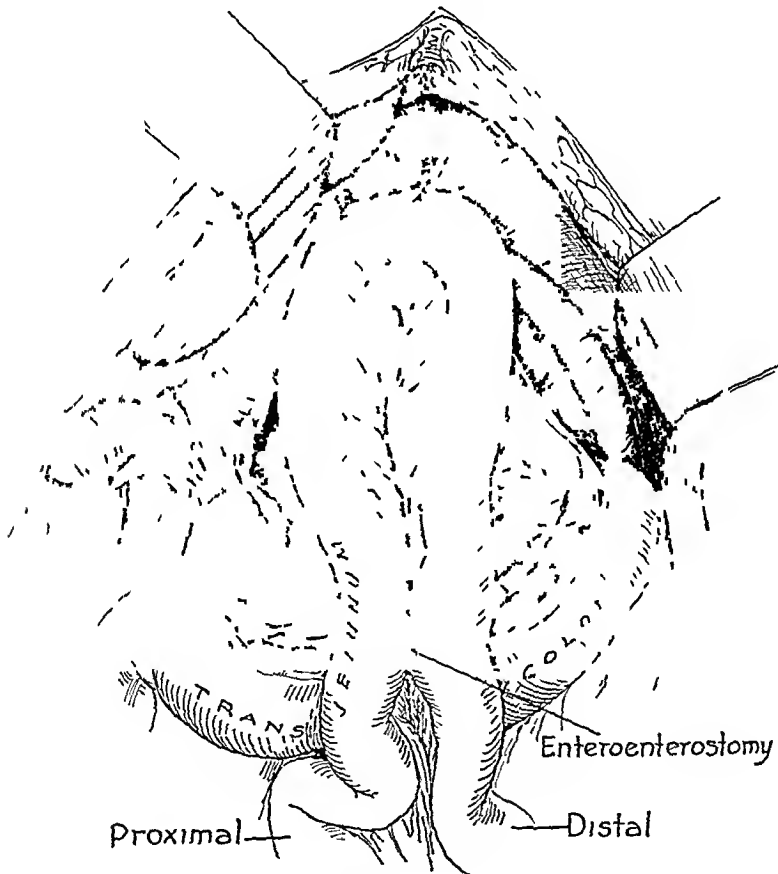


FIG 16—The antecolic esophagojejunal anastomosis with additional suspension sutures to the diaphragm. Note the enteroenterostomy

abdominal wall where the sutures can be introduced more safely and satisfactorily

One of us (S F M) has employed the plan of placing a posterior row of untied silk sutures before the intestine is approximated to the esophagus (Fig 13) This facilitates incision of the jejunum and permits trimming of the mucosa of the jejunum down so that it will fit the esophagus The opened jejunum can then be slipped up against the esophagus as the sutures are gently tied This procedure has a great additional advantage of permitting the esophagus to be held wide open by stay-stitches during anastomosis (Fig 14)

In our early cases, postoperative dilatation occasionally was required because of narrowing of the anastomosis between the esophagus and jejunum In one patient, shown by autopsy to have had no recurrence, we feel sure death could have been avoided had the family physician sent him in for a dilatation when late narrowing of the anastomotic opening occurred, and starvation resulted

Entero-enterostomy, which has been employed by one of us (S F M), has the advantage of relieving any pressure on the suture line where, as the result of swelling at the anastomosis, there is interference with the passage of fluid from the proximal to the distal loop (Fig 16) In addition, it has the advantage of side-tracking a considerable portion of the irritating bile and jejunal content into the distal loop and avoiding esophagitis which occasionally results We will, we believe, now make it a routine part of total gastrectomy

Anastomosis between the jejunum and the cut end of the esophagus is impossible without some soiling from esophageal content Therefore, it is advisable to introduce 4 or 5 Gm of sulfanilamide under the diaphragm about the esophagus to protect against infection Drainage has not been employed

RESULTS

As stated before, 24 patients in this group of 73 patients failed to survive operation, a total operative mortality of 33 per cent (Table I) But of the 28 patients submitted to total gastrectomy in the last two years only five have died, a mortality for that period of 18 per cent

TABLE I
CAUSES OF DEATH IN 24 PATIENTS WHO FAILED TO SURVIVE
OPERATION

Peritonitis	14
Shock	2
Coronary occlusion	2
Myocardial failure	2
Pulmonary embolism	2
Bronchopneumonia	1
Mediastinitis	1
Total	24

As would be expected, most deaths were due to intra-abdominal infection. Because of age and grave nutritional changes, these patients obviously are a poor risk group and withstand peritoneal contamination poorly. The rarity of serious pulmonary complications is gratifying, only one patient in this group having died of pneumonia. This is due to better anesthesia and to early recognition and treatment of pulmonary atelectasis by suction bronchoscopy. There were two deaths from shock which undoubtedly represent, in our early experience, too much surgery on extremely poor risk patients.

One would expect mediastinitis to be a more frequent complication in view of the fact that the route to the mediastinum is opened by dissection about the esophagus. However, prevention of soiling, together with careful sealing off of the mediastinal region by suturing the peritoneal flaps of the diaphragm to the esophagojejunal anastomosis, appears to prevent this serious complication.

With added technical and selective experience, the operative mortality following total resection definitely has diminished. Factors affecting this decrease have been discussed, but the fact remains that the prognosis depends largely upon whether the tumor is limited to the stomach or already has invaded the lymph nodes. Most malignant conditions of the stomach are diagnosed late when there is extensive involvement of gastric tissue with invaded adjacent lymph nodes, even though they may not be macroscopically apparent. It is in these cases that we commonly employ total gastrectomy. The prognosis then depends upon the pathology of the growth and the absence of distant metastases. Even though gross involvement of adjacent lymph nodes may not be apparent at operation, in practically all our cases lymph node invasion was noted upon microscopic study. Obviously, most of the resected malignant lesions were carcinomatous, and 87 per cent showed lymph node invasion. Whether the neoplasm was carcinoma simplex or adenocarcinoma seemed to make little difference in prolongation of life. More favorable results were obtained in those patients whose tumors were lymphoblastomatous or leiomyosarcomatous in type. There were five lymphoblastomas and two leiomyosarcomas.

With such a high percentage of lymph node involvement, the opportunity for cure is limited. However, even with recurrence the opportunity to prolong life is considerable. In our own experience with explored and nonresected carcinoma of the stomach, the average life expectancy is five months. If we can expect a period of reasonable comfort for the patient and if the surgical hazard is not too great, total gastrectomy is justified.

In addition, there is always the possibility of cure, as in the case of a young woman now alive and well, who had a total resection six years ago for a leiomyosarcoma involving the entire stomach and previously closed as inoperable. It is well to emphasize that although recurrence will occur in the majority of cases and prove fatal, these patients enjoy freedom from marked gastric distress and when recurrence does take place, it commonly appears

TOTAL GASTRECTOMY

in the liver, peritoneum and retroperitoneal lymph nodes and very rarely involves the esophagojejunal anastomosis

TABLE II
SURVIVAL PERIOD IN 23 PATIENTS WHO DIED OF RECURRENT
MALIGNANCY

Less than 6 months	3
6 months to 1 year	6
1 year to 18 months	6
18 months to 2 years	6
2 to 3 years	1
3 to 4 years	1
Total	23

Table II shows 23 patients who survived operation and subsequently died of recurrence of their malignancy. Of these 23, only three failed to survive less than six months. Therefore, only three of 23 patients who ultimately died of recurrence lived a shorter period of time than they would have if they had not undergone surgery. Fourteen of the 23 lived one year or longer, one of which lived over two years and another over three and a half years. Furthermore, the death of these patients from recurrence was not more distressing than in the unoperated group, and in the majority was even less so. In most of these patients, death was due to cachexia or terminal bronchopneumonia.

TABLE III
SURVIVAL PERIOD OF 26 PATIENTS WITH NO RECURRENCE
FOLLOWING TOTAL GASTRECTOMY

Less than 6 months	8
6 months to 1 year	6
1 year to 18 months	4
18 months to 2 years	3
2 to 3 years	1
3 to 4 years	1
4 to 5 years	1
5 years plus	2
Total	26

Of the 73 patients undergoing total gastrectomy, 26 patients are alive and as yet present no definite evidence of recurrence (Table III). Eight were operated upon too recently (less than six months ago) to evaluate the results, and six others have survived for six months to a year. Twelve patients, or nearly half of those alive, have lived a year or longer since operation.

All of these patients are seen at intervals and apparently are in reasonably good health. They are able to take sufficient nourishment to maintain their weight and in some cases even gain in weight. After several months, most patients have been able to carry on their usual activities and employment. One woman, age 35, has been alive and well for four and a half years. A man, age 50, has survived operation for four and a half years after total

gastrectomy for adenocarcinoma of the cardia. A woman, age 33, is well six years after total gastrectomy for leiomyosarcoma.

Late postoperative obstruction of the lower end of the esophagus at the site of the anastomosis with the jejunum may occur. Symptoms of esophageal obstruction do not necessarily mean recurrence of tumor, and in the majority of cases are due to scar tissue narrowing which may easily be corrected by dilatation. We have emphasized the importance of avoiding any narrowing of the esophagus at this point during suturing of the jejunum to the end of the esophagus. If difficulty in swallowing as the result of scar tissue contraction of the stomachal orifice should develop, it may be corrected by simple dilatation with an olive-tipped bougie passed over a swallowed string. Fluoroscopy will disclose the source of the dysphagia, and if necessary, direct esophagoscopy can be employed to rule out recurrent malignancy.

POSTOPERATIVE FEEDING AND DIET

The feeding of patients after complete extirpation of the stomach is divided into stages. In the first stage, the main objective is to supply the patient with some fluid and nutrition, without putting any strain on the suture line. In the second stage, the objective is to establish the patient on a feeding program which will supply him with sufficient calories and other dietary essentials and at the same time prevent the occurrence of certain symptoms which are largely mechanical and due to the loss of the stomach.

For the first three days postoperatively, nothing is given by mouth and fluids are supplied parenterally. On the fourth day, 1 oz. of water is given by mouth every hour. On the fifth day, 1 oz. of malted milk or gruel, made with water, is added at hourly intervals so that the patient gets 1 oz. of fluid every half hour, alternating water and malted milk. On the sixth and seventh days, these quantities are increased 1 oz. each day, and on the eighth day, a single feeding of soft, solid food, such as custard, soft egg, or cooked cereal is added. From this point on daily increases in the food intake usually are well tolerated, but for the first 15 days postoperatively, only soft solids and liquid foods are permitted.

Supplementary vitamins should be supplied by giving the patient orange juice diluted with water, half and half, in 3 oz. quantities in place of the plain water, at least three times a day. Parenteral injections of vitamin B complex in 1 cc. doses should be given daily beginning immediately after the operation, and continued for about ten days, when the oral administration of vitamin B complex can be substituted.

The second period of dietary management begins about 15 days postoperatively, when the permanent maintenance program is started. A liberal and varied diet should be prescribed, including meat and vegetables, bread and fruit, with the following consideration. The jejunum, which is anastomosed directly to the esophagus, should be protected against trauma from the swallowing of rough or coarse food. If the patient cannot chew his food well, the meat should be ground. Only cooked fruit and vegetables should be

given, and if the vegetables are cooked to the point of tenderness, they need not be puréed. Hard, dry crackers or toast should be avoided. The patient should be instructed to eat slowly.

The absence of the stomach at first permits the patient to eat only small quantities of food at a time. For this reason, it is necessary that only small amounts of food be given, but at least six feedings a day are necessary to supply a sufficient caloric intake. He is eventually able to get along on three to four meals a day.

Some patients complain of fullness, weakness and sweating immediately after the ingestion of food. This symptom appears to be due to the rapid distention of the small intestine. Usually eating more slowly, taking less fluid with the meal and using mainly solid or soft solid foods will control this symptom.

In spite of the loss of all the gastric tissue, a primary type of anemia has not been encountered after total gastrectomy. Postoperative secondary anemia is a frequent complication to be watched for, and when it does occur, the patient should be put on a regular maintenance dose of liver extract parenterally.

SUMMARY

The operative mortality of total gastrectomy definitely has diminished. Twenty-eight operations have been performed in the last two years, with five deaths, a mortality of 18 per cent. Seventy-three cases are reported, with 24 deaths. The operative mortality for the whole group is 33 per cent.

The indications for total gastrectomy are discussed, and the careful selection of patients whose lesion is suitable for total gastrectomy is emphasized. Care must be exercised to avoid resection in hopeless cases.

Technical methods which we have found valuable in performing this operation are described and illustrated.

Prolongation of life may be expected in a large percentage of patients, but few if any cures will result from total gastrectomy except possibly in the leiomyosarcomas.

Out of 48 patients surviving total gastrectomy, 15 patients lived for a year or longer before recurrence caused their death. Twelve patients are alive and well, having survived one year or longer. Seven have lived two or more years. One patient is alive and well after four and a half years, and another is quite well six years after total gastrectomy.

REFERENCE

- ¹ Lahey, F. H. Complete Removal of the Stomach for Malignancy. Report of Five Surgically Successful Cases. *Surg., Gynec. & Obst.*, 67, 212-223, August, 1938.

DISCUSSION—DR J SHFITON HORSLEY, Richmond, Va Doctor Lahey has been one of the pioneers who has helped to put this operation on the map His suggestions in technic are extremely helpful I think one of the most important is showing that the spleen can be taken out with impunity, because if it is close to the stomach, tacking it up is quite inadequate in many cases

Total gastrectomy, while not as rare an operation as it was a few years ago, is by no means common now The indications for such an operation are infrequent The mortality rate up to recent years has been very high and there has been a general impression that removing all of the stomach would interfere with the hemopoietic process and produce pernicious anemia The mortality rate has decreased in recent years, partly due to better selection of cases and proper after-treatment, and partly also because of improvement in technic Many surgeons have contributed to this improvement Lahey has shown that removal of the spleen with total gastrectomy is apparently of no great consequence In many instances the spleen may be injured while performing this operation or may be closely adherent to the stomach If the spleen is injured, suturing or packing it is often not adequate Allen has shown that suturing the loop of jejunum to the diaphragm tends to lessen traction on the sutures But probably the most important addition to the technic is that of Roscoe Graham, who brings down the esophagus by blunt dissection with the fingers, severs the vagus nerves, and sutures the loop of jejunum as high as possible parallel to the esophagus Then, after dividing the esophagus about an inch lower down, he implants the end of the esophagus into a transverse incision in the jejunum

One of the most interesting articles on the late results of total gastrectomy is by Farris, Ransom and Collier,* in which they review the work that has been done from a physiologic standpoint and the observations they have made on the total gastrectomies done at their Clinic These authors state that the anemia resulting from total gastrectomy, or even sometimes from partial gastrectomy, is not the macrocytic or pernicious type, but is distinctly hypochromic microcytic or secondary anemia, which is usually associated with iron deficiency It is well known now that organic iron in food is not available for absorption unless released by peptic or tryptic ferments This holds true equally if there is achlorhydria Ferrous iron (sulphate chloride or carbonate) seems to be the only form in which iron is satisfactorily absorbed from the alimentary canal According to these writers, the administration of ferrous sulfate three times a day for one week out of every month prevents this secondary anemia After a few months the patient is able to take practically any kind of food, though it must be in smaller quantities and at more frequent intervals

I have performed 16 total gastrectomies The first was in 1929, and Waltman Walters, who reported a case at that time, said there were only 70 cases on record in the literature My twelfth case was operated upon in March, 1942 All these patients died following operation, and all the operations were for very extensive cancer except one, that was for multiple ulcers, one of them perforating from the cardiac end of the stomach Two of the deaths were from pneumonia, one from shock, one from volvulus of the bowel between the entero-enterostomy and the esophagus, and one from thrombosis of the superior mesenteric vessels The other deaths were from infection, subdiaphragmatic abscess, or general peritonitis In four cases the sepsis resulted from a leak at the suture line, in the others, sepsis developed apparently independently of a leak

Postmortem examinations were held in 11 of the 12 cases and some knowledge was gained from most of these In the patient that died from volvulus of the jejunum between the entero-enterostomy, and the esophagus, there seemed to be an indication for a "three-point landing," uniting the right limb of the jejunal loop to the stump of the duodenum This not only stabilizes the loop and prevents a volvulus, but gives an adequate exit for the contents of the duodenum In addition to that, I have been placing a rather large drainage tube into the esophagojejunal anastomosis and suturing it there with chromic catgut This enables the jejunum to be pulled well up over the anastomosis without fear of causing obstruction The enterostomy for feeding purposes is made with a mushroom catheter a short distance below the entero-enterostomy The entero-enterostomy is made

* Farris, J Matthews, Ransom, Henry K, and Collier, Frederick A Total Gastrectomy Effects upon Nutrition and Hematopoiesis Surgery, 13, 823-832 June, 1943

by the rubber band technic described in the October, 1943, issue of the ANNALS OF SURGERY, and in a paper to be presented by me before the present session of the Southern Surgical Association. The technic is simple and reasonably safe.

It is rather remarkable that I should have had four cases this year, all of them successful from an operative standpoint.

CASE REPORTS

Case 1—W B L, a woman, age 50, was admitted to St Elizabeth's Hospital May 24, 1943. She gave a history of having had "stomach trouble" for 12 months and had lost 25 pounds in weight. She had had pain four or five hours after eating. There were nausea and vomiting, with relief after vomiting. On admission, gastric analysis showed free hydrochloric acid 10, 30 and 70 in the three half-hour specimens. The blood examination showed Hb 75 per cent, RBC 4,070,000, WBC 7,650. The operation as described was performed May 28, 1943. It was necessary to remove the spleen. There was involvement of the pancreas near the region of the gastric artery. The adherent portion of the pancreas was excised with the hot electric cautery. She made a very satisfactory recovery, her temperature was never above 99.8° F except on June 10, when she had an attack of pyelitis. She was discharged from the hospital June 24, 1943. Her family physician, Dr E L Johnson of Bedford, Va, who referred the patient, reported on September 1, 1943, that she was in very good condition and doing much of her housework. A letter received from the patient on September 8 says she has an excellent appetite, can eat almost anything, usually has some discomfort for a short time immediately after meals, and is feeling quite well. This discomfort is doubtless due to distention of the jejunum, and should disappear.

Case 2—R T C, a man, age 64, was admitted to St Elizabeth's Hospital July 12, 1943. He gave a history of intermittent severe epigastric pain for several years. The pain had been worse during the past eight months, during which time he had lost 40 pounds in weight. For the past two weeks there were repeated gastric hemorrhages. On admission his hemoglobin was 24 per cent, RBC 2,070,000. On the following day he had hemiplegia of the right side. Numerous transfusions were given with only a temporary rise in hemoglobin. Gastric analysis showed no free hydrochloric acid in any of the three half-hour specimens. Roentgenologic examination showed marked gastric retention. The examination was repeated several days later but was not satisfactory as the paralysis prevented manipulation. It was apparent that the patient would bleed to death. On August 3, 22 days after admission, he was operated upon under local anesthesia. As in the previous case, there was slight invasion of the pancreas in the region of the gastric artery. This affected portion of the pancreas was dissected off, remaining attached to the stomach, after clamping and dividing the gastric artery. The cancer was extensive. The operative technic described was used. He made a satisfactory recovery, his temperature was never above 100.5° F, and he left the hospital August 25, 1943, 22 days after operation. His paralysis had somewhat improved and his general condition otherwise was very good. He died November 6, 1943, apparently a cerebral or cardiac death.

Case 3—W M, a man, age 60, was admitted to St Elizabeth's Hospital August 31, 1943, with a history of general weakness, substernal and epigastric discomfort for the past six months, with a loss of 12 pounds in weight during that time. On admission to the hospital, the blood examination showed hemoglobin 48 per cent, RBC 3,450,000, WBC 6,000. Gastric analysis gave no free hydrochloric acid in any of the three half-hour specimens. Roentgenologic examinations revealed a very extensive gastric lesion. He was operated upon September 3, 1943, under ethylene anesthesia, by the technic described. His gallbladder, while not involved in the neoplasm, was very tense and adherent, and was removed. There was extensive cancer along the lesser curvature. He made an uneventful recovery.

Case 4—R H G, a man, age 46, was admitted to St Elizabeth's Hospital October 19, 1943. He was operated upon October 21, 1943. He had a very extensive perforating ulcer from the cardiac portion of the stomach into the pancreas. There were also three other ulcers near the pyloric end of the stomach. In removing the large lesion, which had as its base the pancreas, it was at first thought that it was malignant, although it could not be well removed without sacrificing so much of the stomach as to make total gastrectomy indicated. The portion of the pancreas that was resected was mostly necrotic. In a few days the patient developed a pancreatitis which blocked the common duct as well as the pancreatic duct, and the icterus index gradually went up from 18 seven days after operation, to 100 14 days after operation.

The liver was somewhat enlarged. A cholecystostomy was performed, and the gall-bladder was found dilated and contained much bile. The patient gradually improved and at present, while still in the hospital, is doing well. The margins of the ulcer showed definite inflammation and epithelial hyperplasia but no malignancy.

After losing 12 consecutive cases of total gastrectomy, the successful outcome in four consecutive cases is somewhat gratifying, but in looking back, it is humiliating to recall that if the technic that I have adopted now had been used then, many of these patients that died might have recovered. The improvement in this technic, aside from the general preparation of the patient and the selection of the cases for operation, consists in the principle of Roscoe Graham in making the esophagojejunal union, the insertion of a large rubber tube in the anastomosis which permits the telescoping of the esophagus into the transverse incision in the jejunum without occluding the lumen of the anastomosis, the uniting of the right limb of the loop of jejunum to the stump of the duodenum, the aseptic entero-enterostomy by the rubber band technic, and the use of sulfanilamide and sulfathiazole in the peritoneal cavity.

DR ROGER D DOUGHTY, Columbia, S C. I have just one word to say. We are still faced with the problem of early recognition of carcinoma of the stomach. I would like to report the death of a patient nine years following a subtotal resection for early carcinoma, performed by Doctor Finney. In my personal experience, which is very limited, this is the longest survival which has come to my attention.

DR SAMUEL F MARSHALL, Boston, Mass. (closing). Doctor Lahey has emphasized the necessity for critical selection of those patients to be submitted to total gastrectomy. Obviously, we must make the final decision after the abdomen is opened. We may suppose from the roentgenologic, and other findings, that it is possible to do a total resection, but our positive decision must be made at the time of abdominal exploration. I think it is important to point out that it is well first to visualize the esophagus and determine whether we have enough esophagus uninvolved to make a safe anastomosis. Furthermore, we must make certain there is no extension of the tumor to the pancreas or dissemination to the lymph nodes. It is perfectly useless to attempt to do a total gastrectomy if we cannot take out all the tumor. It is embarrassing to mobilize the stomach and then find that the tumor extends much further than anticipated.

I think that all our efforts have been toward developing a more simple operation, and toward that end Doctor Lahey has suggested the addition of splenectomy to the procedure. I must confess I was hesitant to adopt this at first because I was afraid of the added mortality, but in going over the data I am certain this fear was not justified. Our mortality has not been increased and the operation has been greatly simplified with splenectomy. We have done 28 total gastrectomies over the last two years and our mortality has dropped to 18 per cent.

There is one other point of significance, and that is, the problem of dysphagia that occurs occasionally after operation. We must attempt to prevent narrowing of the esophagojejunal anastomosis during the operation, but if this does follow operation it can be readily handled and very easily diagnosed by direct esophagoscopy and by fluoroscopy. Therefore, dysphagia is not necessarily evidence of recurrent malignancy, and such a diagnosis should not be made without adequate proof.

We have seen hypochromic anemias of the secondary type and, as Doctor Horsley has pointed out, they have been easy to handle. We have had no anemias similar to primary anemia develop after operation.

ACUTE PERFORATION IN GASTRODUODENAL ULCERATION WITH SPECIAL REFERENCE TO END-RESULTS*

W. L. ESTES, JR., M.D., AND B. A. BENNETT, JR., M.D.

BETHLEHEM, PA

THE PRESENT WORLD WAR CONFLICT and all its attendant alteration of the normal in living conditions, environment, and emotional strain has again brought the problem of gastroduodenal ulceration, "peptic ulcer," to the fore. The tendency to reactivation of this prevalent gastro-intestinal lesion that war time conditions provide would seem to make timely a consideration of the outcome and end-results of one of its most serious complications.

An analysis, therefore, has been undertaken of 80 consecutive cases of acute perforated gastroduodenal ulceration which were treated at St. Luke's Hospital between the years 1928 and 1942, inclusive. There were seven postoperative deaths, an operative mortality of 8.7 per cent. Of the 73 cases who were discharged from the hospital, no satisfactory report of the subsequent course was available in ten. There were ten subsequent deaths, leaving a total of 53 cases who have adequate follow-up records for review. While certain statistical data will be briefly reviewed, stress will be laid particularly on end-results of those recovering from peptic ulcer perforation.

I—INCIDENCE

A Age—The age incidence of patients in this series agrees in general with that of other reports. The greatest number (28.7 per cent) occurred in the fifth decade, 22.5 per cent in the sixth decade, 18.7 per cent in the third decade (Fig. 1). However, the largest number of duodenal perforations (30 per cent) occurred in the third decade, whereas, in the gastric group, the highest incidence was in the fifth and sixth decades (31.2 per cent) (Fig. 2), which might be anticipated inasmuch as the usual onset of *duodenal* ulcer symptoms is before 30 years of age and *gastric* ulcer symptoms, not infrequently until after 40.

B Sex—Of the 80 patients, only two were females, 78 were males (97.4 per cent)—a ratio of one female to 40 males.

C Seasonal—In this series, there were 27.5 per cent perforations in the Spring, 27.5 per cent in the Summer, 22.5 per cent in the Fall, and 22.5 per cent in the Winter. There is, therefore, no indication of any definite seasonal variation. This compares rather closely to DeBakey's figures (collected series) which indicated for the Spring, Summer, Fall, and Winter 24.6, 24.2, 27.9 and 23.2 per cent, respectively.

II—ETIOLOGY

In 40 cases, sufficient historical data were obtainable to indicate a possible etiologic factor for the perforation. These may be summarized as follows:

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

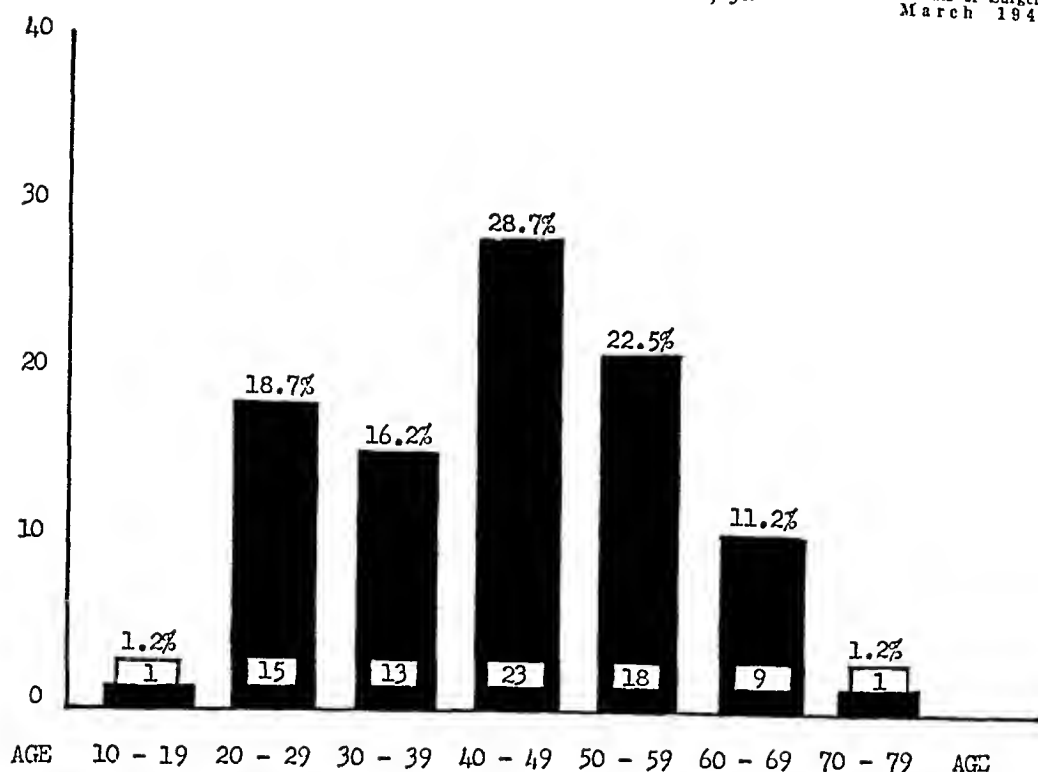


FIG 1—Age incidence in decades of acute perforated gastroduodenal ulceration

POSSIBLE ETIOLOGIC FACTORS	No of Cases	No of Cases	Perforation Occurred
1 Relation to food intake	27	22	16 (72.7%) 3 hours or less after eating
			2 4 hours after eating
			2 5 hours after eating
			2 7 hours after eating
		4	Little food intake for 24 hours
		1	While eating
2 At work (physical strain, long hours)	6		
3 During sleep	2		
4 Trauma—struck in abdomen by crowbar 24 hours before perforation	1		
5 Premonitory pain, dull (1, 2, and 5 days duration)	3		
6 Nervous excitement Spectator at ball game	1		
Total	40		

COMMENT In 27 the intake of food or the lack of it seemed to play a part. Of 22 patients perforating after eating, in 16 (72.7 per cent) the perforation occurred three hours or less after food intake. In one it occurred while eating, and in four there had been very little if any food intake for 24 hours before perforation. Physical strain while at work or extra long hours of consecutive work apparently was a factor in six. In two the perforation occurred in the early morning hours while asleep. The excitement or nervous tension of a spectator at a close athletic contest was apparently

responsible for one, severe trauma to the abdomen 24 hours before in another. In three there was a constant dull premonitory epigastric pain for one, two, and five days, respectively, before perforation occurred.

While numerous etiologic factors in the production of perforation must be recognized, such as excessive intake of food and drink, extrinsic and intrinsic trauma, infection, excessive use of alcohol and tobacco, and local lack of tissues resistance (Shawan, Fallis, DeBakey, Griswold), more than one may readily be implicated in any given case. In this series, food intake,

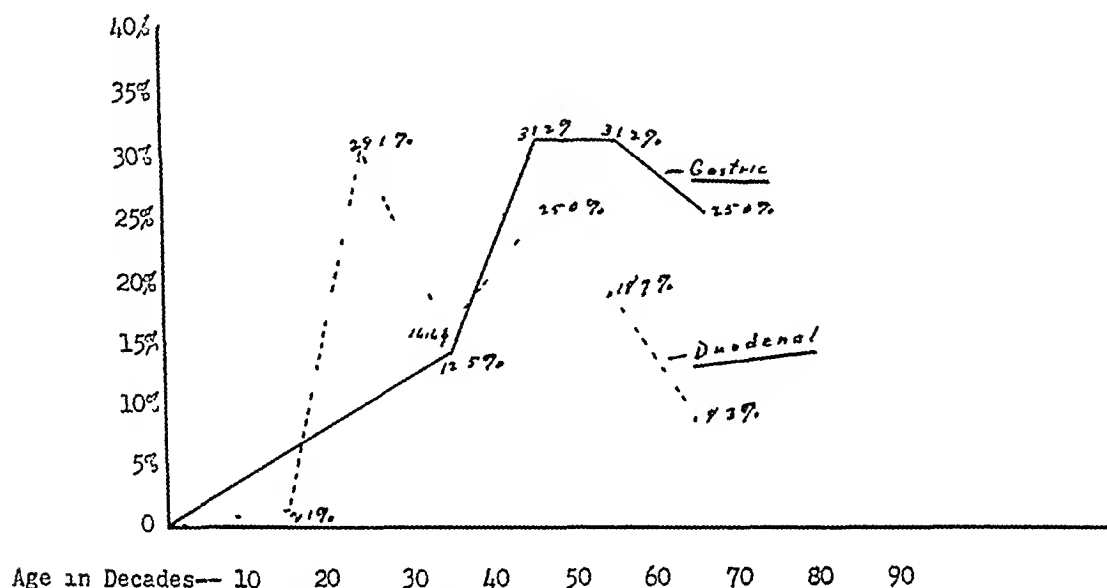


FIG 2—Age incidence of perforated duodenal and gastric ulcer cases contrasted

with its stimulation to gastric motor activity and increase in digestive acids and enzymes, would seem the most prevalent cause of ulcer perforation together with exceptionally long and severe physical strain.

III—PATHOLOGY

Of the 80 cases in this series, there were 63 duodenal, 16 gastric, and one jejunal ulcer, a respective incidence of 78.8, 20, and 1.2 per cent. Of 25 in which cultures from the peritoneal fluid at the time of operation were obtained, eight were positive—two showed *B. coli*, three *nonhemolytic Streptococci*, two *Staphylococci*, and one *Micrococcus catarrhalis*.

IV—SYMPTOMATOLOGY

A General—Of the 80 patients, all presented a history of abdominal pain, sudden in origin, and of great severity. The symptoms in approximately 90 per cent of the cases were of dramatic onset with marked prostration. Agonizing or excruciating pain was most frequently localized in the epigastrium. As a rule the maximum intensity of the pain was promptly attained, but at times it became progressively more intense, apparently when there was leakage down the right lumbar gutter. The pain was unrelenting, never with a

complete remission, and usually intensified by any movement, deep respiration, or coughing. Cases with free perforation and excessive amount of peritoneal fluid had pain radiating to the shoulder, approximately 50 per cent 91·2 per cent of the patients in this series presented an abdominal picture of scaphoid abdomen, board-like rigidity, and extreme involuntary muscle spasm. In the remaining 8·8 per cent without rigidity at operation, it was found that the perforation had been plugged by exudate, the omentum, or by an adhesion to an adjacent viscus, and leaking had temporarily been arrested.

B Preperforation Bleeding—The patients who returned for follow-up examinations were carefully questioned. 26·8 per cent gave a history of evidence of gastro-intestinal bleeding prior to the initial perforation. Several patients who had noticed dizziness, on subsequent questioning recalled having had a tarry stool in association. *Very few* (two) presented evidence of bleeding after the pain of perforation occurred.

C Previous Symptoms of Ulcer—Of the 80 cases, there were three (3·7 per cent) who gave no history of antecedent peptic ulcer symptoms prior to the onset of pain of perforation. Two of these patients have been questioned in the present follow-up and again deny that they had noticed any symptoms referable to their digestive systems. This incidence of patients without previous ulcer symptomatology is low because exceptionally careful inquiry with regard to previous complaint has been made. Many patients who are writhing in the pains of an acute perforation fail to give accurate histories, and as their previous gastro-intestinal disturbances are so mild in comparison with the type of symptoms which they present with an acute perforation, they fail to recall any preceding discomfort. The remaining 77 cases had durations of symptoms ranging from two weeks to 40 years, with a mean average for the group of 4·8 years.

Study of the relative duration of symptoms in perforated gastric as contrasted with perforated duodenal ulcers reveals a striking difference in the older age group. Perforations in individuals over 50 years of age are more likely to be duodenal if the duration of ulcer symptoms has been over five years and gastric if under five years, a finding which could be suspected, inasmuch, as the onset of duodenal ulcer symptoms is usually in the second or third decade and that of gastric ulcer, not infrequently after 40 years (Fig. 3).

D Blood Pressure—Of the 77 cases who have records of blood pressure on admission, no systolic values were found to be below 80 Mm. of mercury. In 47 the systolic pressure was between 110 and 130, in 14, over 130 (i.e., in 76 per cent 110, or over), in 16 the systolic pressure was under 110, of which only six were under 100 (7·8 per cent). Profound shock has not been found to occur in any single instance in this series. However, practically all our cases were first examined at least two hours after perforation. One of our patients was seen within 20 minutes following perforation. In this case there was a transitory period of pallor and sweating with mild shock,

but the blood pressure did not fall below 90 systolic, following which the pulse was full, not accelerated, and the systolic pressure rose to 120 and remained at this level until operative intervention. It is possible that if shock occurs following perforation of a peptic ulcer it is transitory and that by the time patients usually reach the hospital it is not in evidence. Our experience indicated that the patients entering the hospital two or more hours after perforation of an ulcer are not in shock, and low systolic blood pressure is rare. Likewise, the pulse is full and the rate is seldom markedly elevated. Fallis also has reported that in his series 55.1 per cent had a pulse rate under 100.

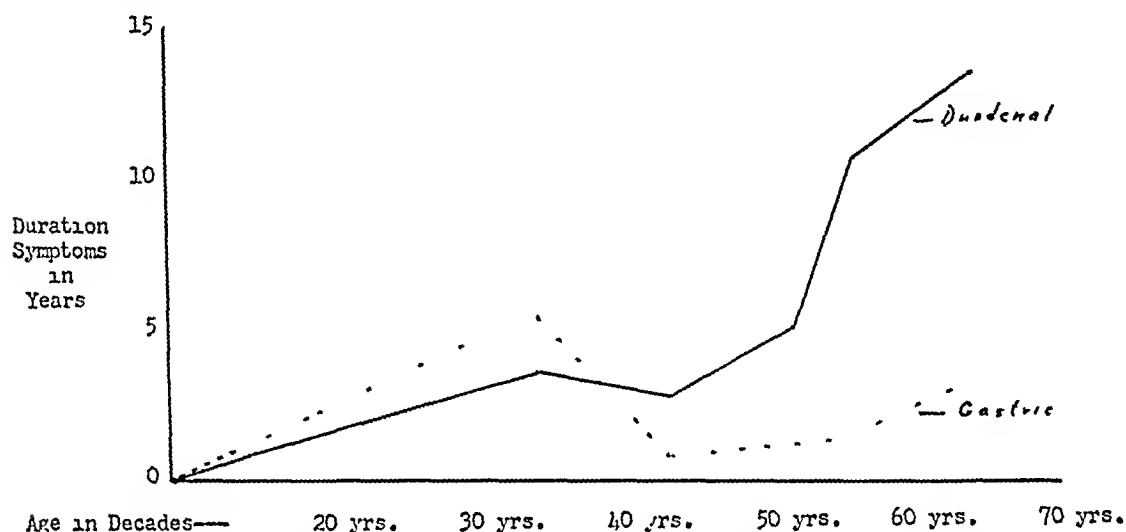


FIG. 3.—Relative duration of ulcer symptoms of perforated gastric and duodenal ulcer

E White Blood Count—In 65 of the 80 patients whose leukocyte counts were recorded, the average white blood count was found to be 15,800. The 15,000 to 20,000 group contained the largest number of cases. Only nine, or 11.25 per cent, had counts under 10,000. It is apparent that irritation of the peritoneal tissues by leakage into the peritoneal cavity from a perforated viscus usually provides a decided stimulus to rapid development of leukocytosis. The increased leukocyte count may, therefore, be an early laboratory finding.

V—DIAGNOSIS

The severe agonizing pain, the scaphoid abdomen often with a transverse depression across the epigastrium (Deaver, Estes), board-like abdominal rigidity with extreme tenderness especially in the epigastrium and the full, not accelerated, pulse is a clinical syndrome not simulated by any other acute abdominal accident. However, when the perforation is temporarily plugged by omentum or the leaking is arrested by a plastic adhesion of a nearby viscus the characteristic clinical picture may not be present nor the signs clear.

An aid to diagnosis in the doubtful or atypical case is the demonstration roentgenologically of pneumoperitoneum. As the reliability of the roentgenographic confirmation of the presence of free air under the diaphragm is now well recognized, it should be considered an important diagnostic adjunct.

Of the 47 cases of this series who had roentgenographic or fluoroscopic examinations performed, air was found under the diaphragm in 34 cases, an incidence of 72.3 per cent, and a negative finding was reported in 13 cases, or 27.7 per cent (Fig 4). There did not seem to be any relationship between the duration of the perforation and the positive finding of pneumoperitoneum.

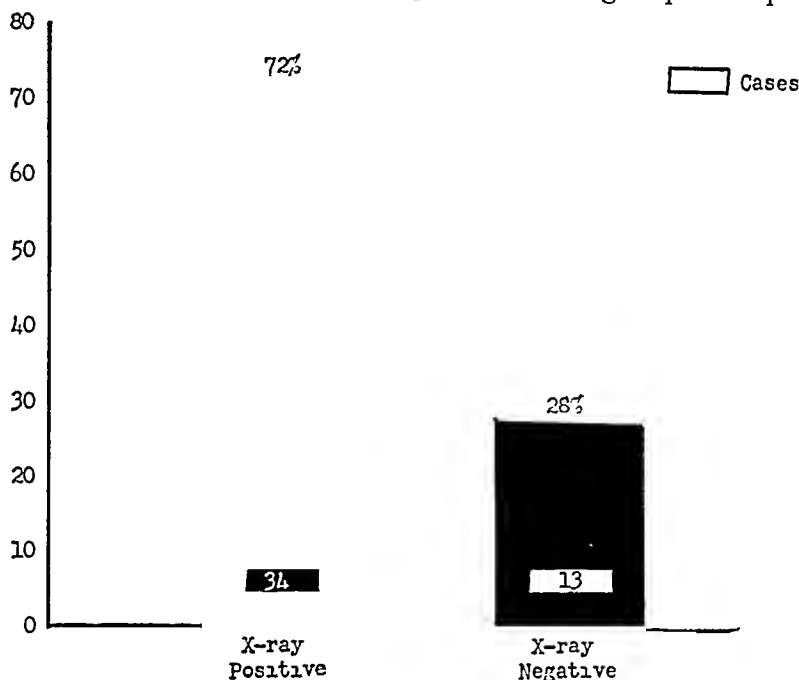


FIG 4—Incidence of roentgen ray evidence of pneumoperitoneum in acute perforated gastroduodenal ulceration

DeBakey, in reviewing the literature, reported a positive incidence of 69.4 per cent in a collected series, and a positive incidence of 64.6 per cent in his own series. In cases in which the roentgenogram does not disclose a pneumoperitoneum, Ochsner and DeBakey have suggested a method for increasing the frequency of obtaining positive films. The stomach contents are first aspirated through a stomach tube, and then a small amount of air, 20 to 30 cc is injected through the tube. The patient is allowed to rest in the left lateral decubitus position and is fluoroscoped. After a few minutes, the patient is placed in a sitting position and another examination with the fluoroscope is made. If the wall of the stomach or duodenum is perforated, air will be found under the diaphragm. In this series, this test has not been carried out, but the rationale seems sound, especially in those cases where the diagnosis is questionable.

VI—TREATMENT

A TYPE OF OPERATION			
Type of Operation	Cases	Per Cent	
Simple closure	61	76.3%	
Excision and closure or pyloroplasty	15	18.7%	
Closure and gastro enterostomy	4	5.0%	

Simple closure of the perforation was done in 61 cases (76.3 per cent),

excision of the ulcer plus closure or pyloroplasty, 15 cases (187 per cent), and simple closure plus gastro-enterostomy in four (5 per cent). For the last ten years simple closure alone has been done. We hold, with Graham, that the patient with a perforation should be treated solely for the lesion creating the emergency. The responsibility of the surgeon is to save life and

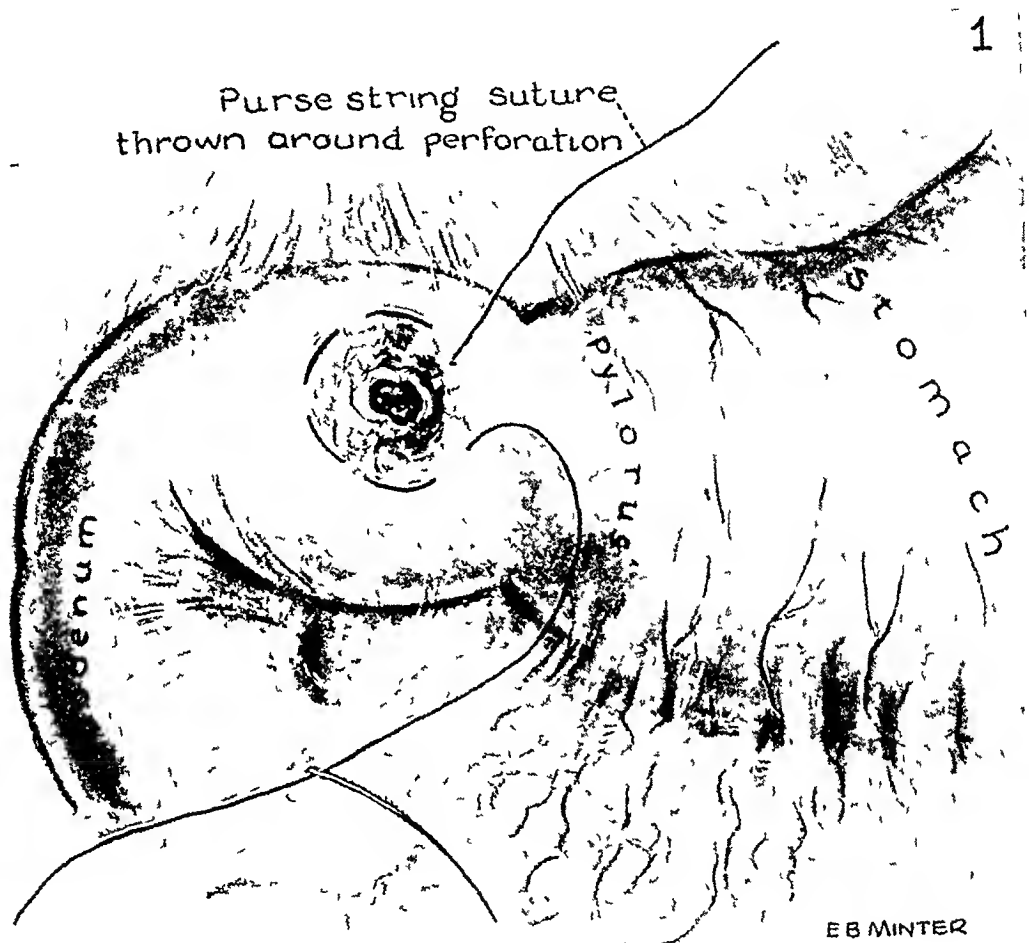


FIG 5—Closure of perforation of duodenal ulcer

the simplest procedure that satisfactorily meets the emergency is the operation of choice. In the face of perforation, the surgeon should be primarily concerned with the patient's recovery from the intra-abdominal catastrophe and not from the ulcer.

B. *Technic of Operation*—(Simple Closure) The technic we have employed for simple closure of the perforation is very similar to that described by Gatch and Owen. Spinal anesthesia is the anesthetic of choice. An upper right rectus incision gives a quick and adequate exposure. After aspirating any fluid in the subhepatic space, the approach to and ease of manipulation of the ulcer area may be facilitated by the introduction of a stay-suture through the superior border of the duodenum or stomach at the level of the perforation. A purse-string suture of No. 00 chromic catgut is then thrown around the perforation at a distance of at least 1 to 1.5 cm from it. This is tied snugly, not with great tension, simply to close off the perforation and prevent further leakage (Fig. 5). Then the ulcer area is buried, enfolded,

and pushed backward beneath two layers of No 00 chromic catgut sutures, placed transversely to the long axis of the intestine beginning at the margin of the gastrohepatic omentum, and in the case of a duodenal ulcer suturing stomach wall to duodenal wall (Fig 6) There is little tendency to narrow or stenose the lumen of the duodenum by these sutures, the ulcer area is merely enfolded and pushed backward and the perforation well closed and

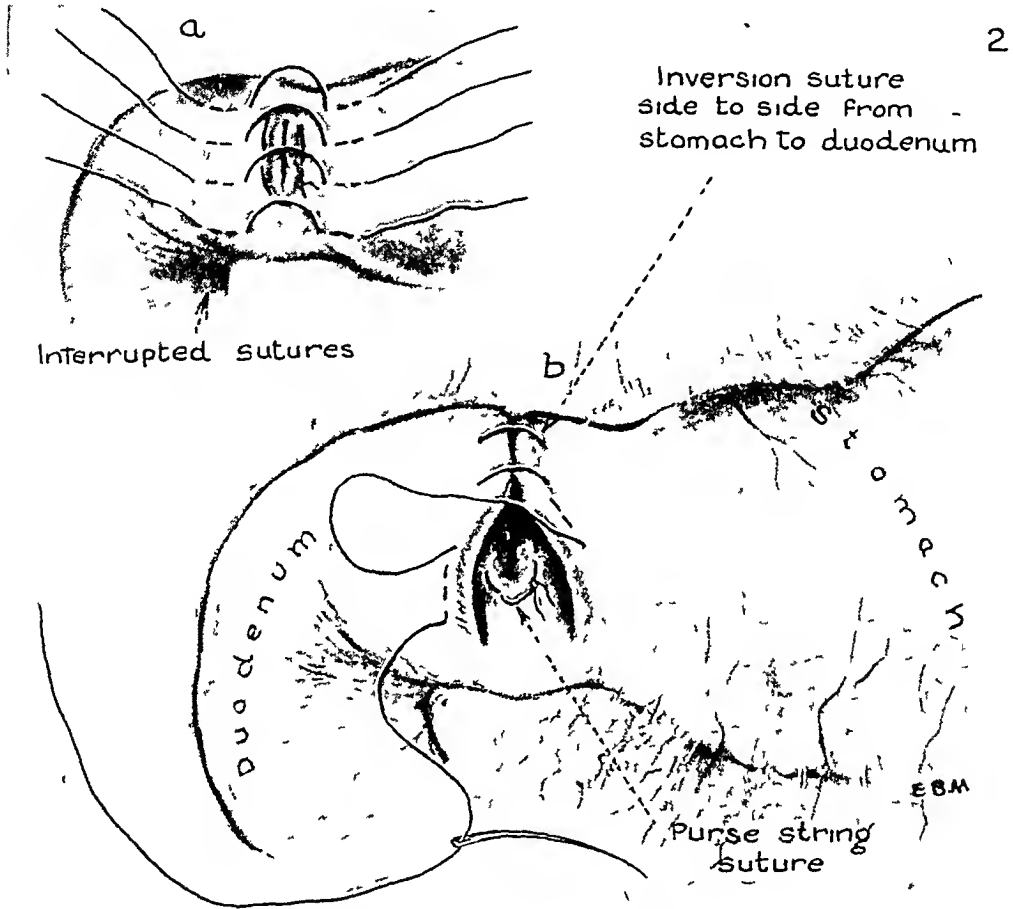


FIG 6—Closure of perforation of duodenal ulcer

covered (Fig 7) Sulfanilamide may be dusted over the suture line and in the subhepatic space Finally, whenever possible, the tip of the greater omentum is placed over the operative site Drainage is only used in the late cases and when, because of the size of the ulcer, or perforation, or extensive induration, completely satisfactory enfolding by suture has not been obtained and further leakage might be possible Drainage in this series was not used in 34 of 38 cases where operation was performed within six hours of perforation

VII—MORTALITY

In the total series of 80 cases there were seven postoperative deaths a mortality rate of 67 per cent Following simple closure in 61 cases (76.2 per cent), there were five deaths, a mortality rate of 8.2 per cent Excision

PERFORATED GASTRODUODENAL ULCER

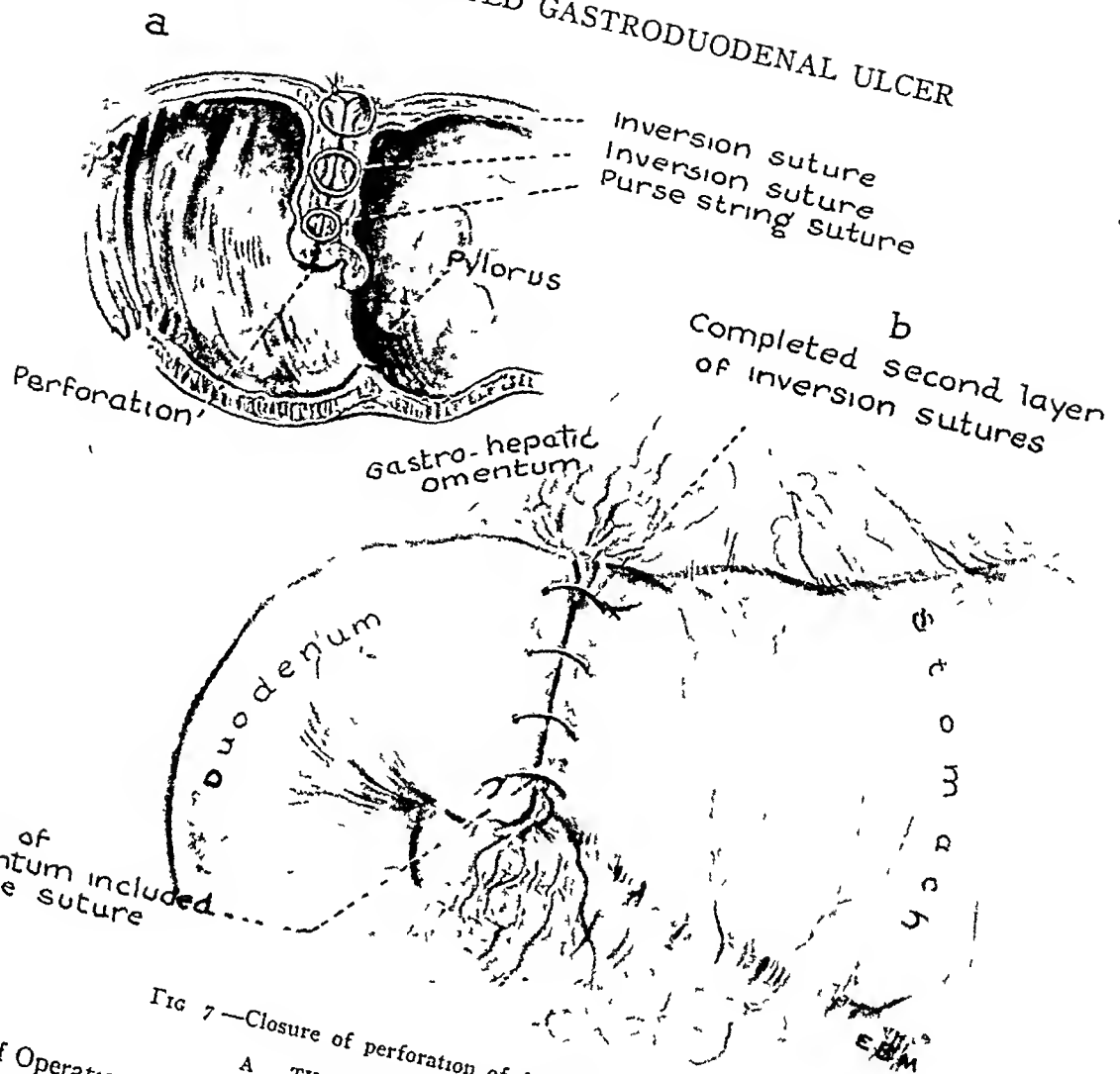


FIG 7—Closure of perforation of duodenal ulcer

Type of Operation
Simple closure
Excision and closure or pyloroplasty
Simple closure and gastro-enterostomy

Cases	Deaths	Mortality Rate
61	5	8.2%
15	2	13.3%
4	0	0.0%

plus closure by pyloroplasty was employed in 15 cases (18.7 per cent), with two deaths, a mortality rate of 13.3 per cent. Simple closure plus gastro-enterostomy was utilized in only four cases (5 per cent), with no deaths. The lower mortality rate in the simple closure plus gastro-enterostomy may be due to the fact that these patients were considered to be in so satisfactory condition that more extensive measures seemed justified. Similarly, in a collected series of 11,284 cases reported by DeBakey, the mortality following simple closure was 25.9 per cent, following closure plus gastro-enterostomy, 20.4 per cent, and following partial gastrectomy, 13.4 per cent. Unquestionably, the better risk patients were subjected to the more extensive procedures which accounts for the lower postoperative mortality of gastro-enterostomy and gastric resection. Thus, however, should not be a valid argument for their more frequent use in the presence of a perforation. Even in the face of apparent lower mortality and even though partial gastrectomy affords a greater chance for freedom from subsequent gastro-

intestinal symptoms, it should be reserved as an operation of election at a later period when full recovery from the acute emergency has taken place and not the operation of choice at the time of the perforation

B DURATION OF PERFORATION

Duration of Perforation in Hours	Cases	Deaths	Mortality Rate
0- 6 hours	38	0	0 0%
6-12 hours	17	2	11 7%
12-18 hours	10	0	0 0%
18-36 hours	6	2	33 3%
36- hours	9	3	33 3%
Total	80	7	8 7%

There was no mortality in the 38 cases operated upon within six hours of perforation. Inasmuch, as this comprised approximately 50 per cent of the cases, it is readily recognized that the low mortality in this series is largely due to early operative interference. 33 3 per cent of those operated upon 18 hours or more after perforation died, indicating, as most other observers have noted, that the mortality following perforation of peptic ulcer lies largely in delay in operation.

The primary causes of death in fatal cases are acute peritonitis, subhepatic abscess, or pulmonary complications. In the seven deaths, three autopsies were obtained. In one, the lethal lesion was diffuse peritonitis, in the second, subhepatic abscess and basal pneumonia, and in the third, diffuse peritonitis, with consolidation in both lower lung fields.

C TYPES OF ANESTHESIA

Type of Anesthesia	Cases	Deaths	Mortality Rate
Spinal	70	5	7 5%
General	9	1	11 1%
Local	1	1	100 0%

Of the 80 cases, 70 received some form of spinal anesthesia, nine received general anesthesia, and one, local infiltration anesthesia, with mortality rates of 7 5, 11 1, and 100 per cent, respectively. Fallis reports a mortality incidence of 7 3 per cent for spinal, 29 3 per cent for general, and 100 per cent for local anesthesia. Shawan's figures indicate that the mortality rate following general anesthesia was twice that of the spinal group. Obviously, local anesthesia is used only in the very bad risk cases and high mortality is to be anticipated.

Although the number of our cases who had general anesthesia may be too small upon which to base accurate conclusions, a comparison of the post-anesthetic complications of spinal and general anesthesia would seem of interest. There were no deaths at the operating table or immediately post-operative with any of the anesthetics employed. In the nine cases with general anesthesia, there were three respiratory complications—two pneumonias and one empyema, an incidence of 33 3 per cent. In the spinal group of 70 cases, there were four pneumonias, one bronchitis, and one empyema, or a total of six complications above the diaphragm, an incidence of 8 5

PERFORATED GASTRODUODENAL ULCER

per cent The intraperitoneal complications following general anesthesia were two subphrenic abscesses, one subhepatic abscess, or three out of nine cases, an incidence of 33.3 per cent After spinal anesthesia, two drainage tract abscesses, three subphrenic abscesses, and five cases of diffuse peritonitis, an incidence of 14.2 per cent

Graham believes that spinal anesthesia is preferable because the pronounced respiratory efforts produced by general anesthesia causes a plunger action of the diaphragm on the liver which tends to disseminate intraperitoneal exudate and leakage over a wider area

COMPARATIVE MORTALITY RATE

Name	Cases	Mortality Rate
Shawan	387	25.43%
DeBakey (collected series)	15340	23.4%
(own series)		18.2%
Eliason and Thigpen	78	21.43%
Guthrie and Sharer	78	20.8%
Fallis	100	20.0%
Shelley	82	18.2%
Griswold	111	18.0%
Paletta and Hill	83	16.9%
Estes and Bennett	80	8.7%
Graham, R. R.	62	3.2%

The relatively low mortality rate in our series would seem to be due largely to the high percentage operated upon early, 50 per cent within six hours of perforation, 81 per cent within 18 hours Spinal anesthesia may also have played a part, as 87.5 per cent had a spinal anesthetic It has been our routine procedure to begin intravenous therapy, either plasma or 5 per cent glucose, on the operating table immediately following the administration of the anesthetic Graham feels that, particularly in the late case, appropriate intravenous therapy preoperatively has been a factor in the low mortality of his series Likewise, postoperative gastric suction and sulfonamide therapy should aid in mortality reduction (Ulfelder and Allen, Griswold) The mortality following gastric perforation in our series was 12.8 per cent, two deaths in 16 cases, and 7.9 per cent following duodenal perforation, five deaths in 63 cases This greater mortality following gastric perforation is in agreement with most previous statistics However, our gastric cases were relatively few

VIII—END-RESULTS

Of the 80 cases of gastroduodenal ulceration in this series, there were seven postoperative deaths, with 73 cases remaining Of this number, no follow-up reports were available on ten, and there were ten known subsequent deaths This leaves 53 cases whose course has been satisfactorily determined for statistical study

There were 61 cases of simple closure, with five operative deaths Of the remaining 56 cases, it has been impossible to trace six Of the 50 patients whose subsequent course has been determined, 11 (22.0 per cent) have had subsequent operations for gastric or duodenal pathology, seven

Operation	A TYPE OF OPERATION		
	Cases Followed	Reoperation	
Simple closure	50	11-(22 0%)	<div> <div> 4—gastro-enterostomy or re-section 7—reperforation </div> <div> 8% 14% </div> </div>
Excision and pyloroplasty	11	2-(18 1%)	<div> <div>1—reperforation 1—gastro-enterostomy</div> <div> 9% 9% </div> </div>
Closure and gastro-enterostomy	2	0- (0 0%)	1—case rehospitalized for control of symptoms

cases being for reperforation. Of the 15 cases treated at the time of initial perforation by the operation of excision plus pyloroplasty, there were two postoperative deaths. No follow-up records are available on two. Thus, 11 cases have been followed. Of these, one has reperfected, and one has had a gastro-enterostomy performed. Therefore, of the 11, two have been subjected to reoperation (18 1 per cent). Of the four patients having simple closure plus gastro-enterostomy, the records of two are not available due to loss of contact with the patient. Of the remaining two, neither has had subsequent operations, although one has had two periods of hospitalization for control of peptic ulcer symptoms.

It would seem, therefore, that recurrence of gastric or duodenal ulcer symptoms may occur after any one of the operative procedures employed for treatment of perforation, and with about equal relative incidence following simple closure or excision and pyloroplasty.

It is to be noted that in the 50 cases of simple closure, excluding the seven cases of reperforation, there were but four cases (8 per cent) requiring subsequent secondary operation as compared to one of 20 (5 per cent) in Gatch and Owen's report, ten of 55 (18 1 per cent) in Guthrie and Sharer's series, 11 of 51 (21 5 per cent) reported by Graham, and 15 per cent as stated by White and Patterson.

B POSTOPERATIVE SYMPTOMS

The 53 cases with follow-up records have been divided into three groups according to their postoperative clinical course. They have been very thoroughly interrogated and their complaints and symptoms very strictly interpreted. The first group are those who have been apparently "cured" by the original operative procedure, the second group includes those in a satisfactory condition with conservative measures effectively controlling symptoms, and the third group includes those whose course has been entirely unsatisfactory.

FOLLOW-UP RESULTS—53 CASES

Group I	
"Cured"	3 (5 6%)
Group II	
Symptoms controlled by medical treatment	38 (71 7%)
Group III	
Symptoms not controlled by medical treatment	12 (22 7%)
Total	53

GROUP I —In this group are included those cases who have presented

no complaints relative to the stomach or duodenum *at any time* since the original operation for perforated ulcer. They have not remained on any dietary restrictions, and have received no alkali, antispasmodic, or other similar medication. This group comprises but three cases. The average time followed was 6.5 years and the average age was 54 years. The site of perforation was duodenal in all three cases. The types of operation performed were simple closure in two instances and simple closure plus gastro-enterostomy in the third. Two perform heavy work, one a farmer and the other an industrial laborer. The third is unemployed. All three state that they do not smoke, two deny indulgence in alcohol, while the third states that he has no untoward gastro-intestinal symptoms following the use of alcohol.

In comparison with the end results of others (Shelley, and White and Patterson report that as high as 44 and 60 per cent, respectively, remain well and free of symptoms), 5.6 per cent cured of this series is an exceedingly low figure, in all likelihood the result of strict interpretation and the inclusion of even minor complaints as indicating possible residual disease.

GROUP II—Included in Group II are all patients who, at any time subsequent to perforation, have found it necessary to utilize any one, or any combination of, the following measures for the control of symptoms: (1) Alkali, (2) restricted diet, (3) antispasmodic, and (4) sedation. Of the 53 cases followed 38 were placed in this group. The site of lesion was duodenal in 33 cases and gastric in five cases. Thirty had simple closure, six had excision plus closure or pyloroplasty, and two had simple closure plus gastro-enterostomy. Of the 29 who smoked, 12 stated that their gastroduodenal symptoms were increased following excessive use of tobacco. Nineteen of the 38 gave history of unexplained periods of exacerbations of symptoms, with spontaneous remission. There was history of postoperative melena in three of the 38 cases. The type of work was heavy in 21 cases, sedentary in eight, moderately active in seven, and two were unemployed.

Twenty of the 38 had voluntarily sought a physician's care for gastroduodenal symptoms at some time subsequent to the operation for perforation. The earning power of 16 of the 38 cases had been impaired due to the patient's gastro-intestinal complaints.

Eleven were noted to have the onset of symptoms while still on convalescent ulcer diet and eight noted onset of symptoms immediately after a resumption of full diet. Three of the 38 cases have followed a careful post-operative medical regimen and have never complained of gastro-intestinal symptoms, but they have not attempted to eat all types of food.

End-results of this group may be summarized as:

(a) Patients who are easily controlled by one or a combination of alkalis, diet, or medication and those who only occasionally require dietary or medicinal measures for relief—17 cases (44.7 per cent).

(b) Those who *quite frequently* require diet and medication for relief of periodic complaint—18 cases (47.3 per cent).

(c) Those patients whose symptoms are controlled with considerable difficulty. These usually employ all the dietary and medicinal measures in order to control their gastro-intestinal symptoms—three cases (8 per cent). It is to be noted that four of this group, while apparently well controlled, re-perforated.

GROUP III—Twelve cases are classified in Group III. These comprise those who had gastroduodenal symptoms to a marked degree which were not kept in abeyance by any of the conservative measures, and also patients who are at present *symptom-free* but who required *operative measures for relief* of their *persistent symptoms subsequent to the first perforation*. Nine of the 12 patients stated that their symptoms had been intensified by excessive smoking. Five confessed to an overindulgence in alcohol, with an accompanying increase in digestive complaints. All 12 described their most prominent symptom as upper abdominal pain with the stomach empty. Eight of the 12 gave a history of spontaneous remissions with subsequent acute exacerbations. All 12 stated that certain types of food, usually heavy, greasy, or highly seasoned, would produce symptoms. Of the 12, eight had been engaged in sedentary occupations and one, moderately heavy work. In ten of the 12, the earning power had been impaired by the digestive symptoms, and eight of the 12 had engaged in irregular hours of work, changing shifts, etc. Eleven of the 12 patients remained on a convalescent ulcer diet following discharge from the hospital. Of these, three patients had onset of symptoms while still carefully following this regimen. Four began to have symptoms with resumption of a more liberal full diet.

Four of the 12 re-perforated. Of these four, in one, after an asymptomatic period of two postoperative years, the first symptom was that of the pain of re-perforation.

Four of the 12 have had subsequent elective surgery, two had a gastro-enterostomy for symptoms of long-standing pyloric obstruction, and two have had partial gastric resection for persistent pain from an active duodenal ulcer. All of these are at present relatively asymptomatic on conservative dietary management without antispasmodic or alkali adjunct therapy.

Four of the 12 were rehospitalized and had their symptoms controlled by energetic medical treatment, which all have followed to date, and all report themselves fairly well controlled. One patient has persistent epigastric pain which has been partly incapacitating even though he has carefully maintained a strict dietary and medical management at home. He has refused hospitalization.

SUMMARY OF END-RESULTS IN GROUP III

Reperforation	4
Subsequent elective surgery	4
Rehospitalized for medical control	3
Treatment refused	1
Total	<hr/> 12

IX—REPERFORATION

Of the 73 cases who were discharged from the hospital we have been unable to follow ten. Sixty-three have been followed sufficiently to obtain a report on the late results. Of these, eight developed reperforation, six were duodenal and two gastric. Seven occurred in cases that had had simple closure of the original ulcer and one following excision and pyloroplasty.

The site of the ulcer of the second perforation *was the same as in the initial perforation* in three, two of these cases being gastric and one duodenal. The remaining five very definitely had an ulceration at a different site from that of the first perforation. The onset of ulcer symptoms in four cases occurred approximately two years following the initial perforation when apparently the patient had been satisfactorily controlled by diet and alkali and had been classified in Group II. These symptoms were the pains of the second perforation. Two began to have recurrent symptoms immediately following their first perforation and persisted for one month and five years, respectively, before the second perforation occurred. Apparently reperforation may, therefore, develop both with a slow insidious onset or with a rather sudden flare-up without premonitory symptoms. One patient with a duodenal ulcer reperforated twice after simple closure in each instance.

Of the eight cases, three presented definite histories of bleeding prior to the onset of the second perforation. One patient noted bloody vomitus six months before his second perforation occurred, the other two, tarry stools within a short period of time prior to reperforation.

Incidence of reperforation in this series (12.7 per cent) is exceedingly high. Of 4,183 cases of perforated ulcer reviewed by Pearse, only 33 reperforated, or 0.69 per cent, of DeBakey's 6,538 collected cases, 74, or 1.1 per cent, and nine of Ulfelder and Allen's 334 cases (2.7 per cent). Pearse believes these figures are low. He found that reperforation occurs after all of the operative procedures used for treatment and about equally in the relative proportion of their use. Repeated reperforation is less common after simple closure than after closure plus gastro-enterostomy.

Inasmuch, as the cause of reperforation in peptic ulcer has been largely conjectural, it seemed of interest to review the records of these reperforated cases to ascertain if any possible etiologic factor might be recognized.

(a) *Occupation*—The majority of the patients in this group were found to do heavy types of physical work. Five worked on eight-hour shifts which varied each week and consequently could not form regular dietary habits.

(b) *Alcohol and Tobacco*—Of the eight patients, four were known to indulge to excess in alcoholic beverages at frequent intervals, with a resulting exacerbation of their ulcer symptoms. Five apparently smoked excessively, and three stated that their symptoms were increased by overindulgence in cigarette smoking and were attenuated after reduction in the amount of tobacco used.

(c) *Subsequent Symptoms*—The five patients still living are employed

at present but are not undertaking any exhausting physical types of work. All are taking frequent feedings throughout the waking hours. Three find that milk helps to control symptoms. Four are satisfactorily controlled by a careful dietary regimen plus alkali plus antispasmodics. The remaining patient has periodic attacks of epigastric pain with remissions. He has refused roentgenologic study to date.

(d) *Gastric Analyses*—Postoperative gastric analyses, obtained in six of the eight cases, all presented readings far above the normal range. The maximum free hydrochloric acid values were 50, 135, 86, 78, 94, and 98, with an average value of 90 for the group. The test meal with histamine was the method utilized in each case except one, where the alcohol test meal was employed. Four analyses were taken following the second perforation which indicated hyperacidity values approximating those following the first.

A comparison of the average acids in the reoperation group with those with but a single perforation is illuminating. The average maximum free hydrochloric acid value for 21 of the single perforation cases was found to be 70. The patients who reoperated, therefore, showed higher acid values than those who did not.

It would seem that these exceedingly high acid values of the reoperation group are not merely incidental findings but represent a possible element of definite pathology which may be in part responsible for the development of subsequent ulcerations and possibly repeated perforation.

(e) *Mortality*—Three patients have died subsequent to discharge from the hospital, a 55-year-old man was one, who succumbed to an acute gastrointestinal hemorrhage six months following his reoperation. He had noted recurrent epigastric pain soon after leaving the hospital and had not sought medical aid for relief of symptoms. The second was a 61-year-old male who developed evidence of pyloric obstruction and had a posterior gastro-enterostomy performed six months after his second perforation, following which he was symptom-free on a bland diet, and died eight years later of coronary occlusion. The third was a man of 29 years of age at the time of his first perforation in 1928. Simple closure was done. He was symptom-free on an ulcer diet until 11 months later, at which time he began to notice return of epigastric pain which was followed in one week by a reoperation of his duodenal ulcer. Simple closure again was employed, the ulcer being in the exact location of the previous perforation. From 1929 to 1940 his symptoms were controlled by a bland diet with frequent feedings. In 1940 he discontinued treatment and in three months developed vomiting and pain. He was treated elsewhere, and a gastro-enterostomy for a duodenal ulcer was performed. In 1941 his symptoms recurred, and he returned to the same hospital for a perforated jejunal ulcer which was treated by plication. His symptoms persisted and two months later he was subjected to a gastric resection from which he failed to recover.

In summary, it may be stated that

(a) Six of the patients with reperforation were in the 30- to 40-year age group and engaged in heavy physical work

(b) A majority used alcohol and tobacco to excess

(c) Six had unusually high free hydrochloric acid values in the gastric analysis

(d) One patient after reperforating developed a third duodenal ulcer that failed to respond to a gastro-enterostomy and required a gastric resection. One reperforated a second time. One has another active ulcer. One died of a gastro-intestinal hemorrhage. One required a secondary gastro-enterostomy.

It would seem that patients who have had a perforation of a peptic ulcer and (1) have irregular working hours, (2) admit dietary indiscretions, and (3) are shown to have high acid values in postoperative gastric analyses, are all likely to be candidates for subsequent reperforation. It is suggested, therefore, that a routine postoperative gastric analyses should be made in all cases recovering from gastroduodenal perforations. In those cases in which repeated analyses show persistent excessive hyperacidity and particularly those difficult to control by diet, alkalis, or other medication, recurrent ulceration with subsequent reperforation is exceedingly likely, and subtotal gastrectomy would seem definitely indicated, not only to protect the patient against further gastroduodenal ulceration but to avoid the danger of a subsequent reperforation.

SUMMARY AND CONCLUSIONS

1 Eighty cases of acute perforated gastroduodenal ulceration treated by operation are reported, with an operative mortality of 8.7 per cent. Of these, 63 were duodenal, 16 gastric, and one jejunal.

2 The clinical syndrome of perforation, as observed at the time of admission to the hospital, is described. Shock is rarely present, systolic blood pressure in 76 per cent was 110, or over.

3 Diagnosis in the atypical case may be confirmed by roentgenologic demonstration of pneumoperitoneum.

4 Simple closure of the perforation is the operation of choice. The method of closure employed in this series is detailed.

5 Low postoperative mortality rate (8.7 per cent) may be attributed to (a) early operative interference, 81 per cent operated upon within 18 hours of perforation, (b) spinal anesthesia, (c) immediate (preoperative) routine use of intravenous therapy (plasma, glucose, saline), and (d) postoperative gastric suction and sulfonamides.

6 End-results have been reported in detail. Of those followed, only 5.6 per cent were completely cured, 71.7 per cent required medical treatment for control, and 22.8 per cent required further surgery or hospitalization for relief. Perforation, therefore, but rarely confers immunity from further ulcer symptoms. Following operation, perforation cases require the same continuous medical supervision that any peptic ulcer case requires.

7 Four of the 50 cases of simple closure followed required secondary gastro-enterostomy or resection

8 Recurrent ulceration was observed after all types of operative measures used for the closure of the perforation

9 Reperforation occurred in eight cases (12.7 per cent)—six duodenal, and two gastric. The common factors that these presented were (a) Dietary indiscretions (b) Overindulgence in alcohol and tobacco (c) Marked gastric hyperacidity

10 It is suggested that of postoperative perforated ulcer cases, those in which repeated gastric analyses show persistent excessive hyperacidity, and are difficult to control by medical measures, recurrent ulceration with subsequent reperforation is likely and partial gastrectomy would seem indicated

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PERFORATED GASTRODUODENAL ULCER

DISCUSSION—DR FRANK K. BOLAND, Atlanta, Ga. I wish to say a few words about this disease in the colored race. Some 30 or 40 years ago it was rare in the Negro, but the incidence of the disease, it seems to me, has increased since that time until now it nearly approaches that of the white race. For a long time I have tried to show that this increase is somewhat a matter of diet. When the Negro adhered to his old diet of "pot likker" and similar common foods with a high vitamin C content, there was very little peptic ulcer, gallbladder disease or appendicitis, but since he has become more civilized and eats more white folks' food he has more white folks' diseases.

We have more perforating than nonperforating peptic ulcers at our hospital. This year we have had something like 30 perforations, with a mortality of 20 per cent. Of course many of these cases come in late, but I note Doctor Estes' statistics show about the same ratio. I believe with spinal anesthesia our mortality would be less.

I wish to report one case, that of a Negro who had been sick for four days before entering the hospital. He had had several episodes of epigastric pain during the past few years. When he came to the hospital he was in shock, so much so that while the diagnosis of perforated ulcer was made we could not get him into condition to operate, we gave several blood transfusions and other supporting measures. He had bulging in both flanks and evidently an accumulation of fluid (slide). This is the roentgenogram, and I would like to call attention to two points, one is the pneumoperitoneum all over the left side, this is very marked and looks like a pneumothorax in the chest. He had more free pus than I have ever seen in the abdomen, about 1,000 cc. was evacuated from each side when the tubes were put in (slide).

The autopsy showed the largest perforated ulcer I have seen, 2 cm. in diameter. I notice Doctor Estes showed one large perforation in a drawing, but mine is from an actual autopsy specimen and diagnosed by the pathologist as prepyloric ulcer. So this case had this large perforation, a marked amount of pneumoperitoneum and a half-gallon of pus which was aspirated from the peritoneal cavity.

DR J. M. T. FINNEY, Baltimore, Md. I think we are all very much indebted to Doctor Estes for a most comprehensive and detailed study. I want to call attention once more, as I did a few years ago, to a very simple method of closure of a ruptured ulcer which was first described, I believe, by one of our Senior members, Doctor Miller. I have employed it in 29 cases in the last eight years.

I think most of us have realized the difficulty of placing sutures in the tissue around the ulcer and have them hold, because of edema and scarring they almost invariably tend to cut out. Also I believe we have been impressed by the danger of constricting the lumen. Doctor Estes felt he could close without too much constriction—I have not had that luck.

The method advocated consists in dividing and detaching the round ligament of the liver from the under surface of the abdominal wall near the umbilicus, it is a rather fibrous structure in most people. If one then takes the cut end of the round ligament, leaving the upper end attached to the liver, and sutures it tight against or even into the perforated ulcer, and for about one centimeter around the perforation, there is a solid plug which will close the hole and effectually cover the wall around the perforation. One does not have to pull the sutures to close the hole to make it secure, so the sutures do not tend to cut out, it is easy to place a plug to cover a considerable area and in that way to block off not merely the perforation but a large area around it.

Using that method, in 29 cases I have had one death in the last eight years, and that was a perforated gastric carcinoma. I have employed it in one gastric ulcer and 27 duodenal ulcers. To date I have not had occasion to reopen any of these cases for reperforation or for stenosis. Whether they have gone elsewhere for a second operation I do not know, because I have not followed them all. Most of them came from around Baltimore and I believe I should have heard had any come to second operation. I realize one is skating on thin ice and no doubt there will be secondary operations, but personally I have had more satisfaction with this procedure than with any other.

DR CLAUDE J. HUNT, Kansas City, Mo. I have enjoyed this presentation by Doctor Estes. He has covered the subject so thoroughly that there is little to be said in discussing his paper. He has emphasized the relative frequency of pneumoperitoneum in the perforation of peptic ulcer. We think this is a positive diagnostic procedure and

is of great value when it is present. If the perforation is free into the abdominal cavity one can usually find evidence of pneumoperitoneum. If the patient is elevated and in somewhat a sitting position, air can usually be seen between the liver and the diaphragm. However, the absence of free air in the abdominal cavity should not cause one to delay operation if there are clinical manifestations of perforation.

We feel that at operation only such measures should be taken as will result in the restoration of the patient to health and save his life. The situation is a tragic one, accompanied by shock, and demands immediate operation upon a patient unprepared for major surgery. Therefore, we believe that simple closure and nothing else should be attempted. We believe that further surgery should be deferred until the patient is sufficiently recovered from the tragedy and the shock so that he may be adequately prepared for a gastric resection. It is rarely necessary to do a gastro-enterostomy at the time of preparation. We have felt it necessary to do so only twice in our experience. We have not done a partial gastrectomy at the time of primary closure. We have, however, on several occasions, reopened the abdomen at a later date and done a partial gastrectomy.

The question of frequent perforations at the same site is emphasized in the following case. A boy, at the age of 17, had the first perforation, and at the age of 23 had the fourth perforation. The fourth one we closed, the three previous ones were closed elsewhere. Subsequent to the closure of the fourth perforation we did a partial gastrectomy from which he recovered nicely and has remained well to date. This emphasizes the fact that one may have multiple perforations and that with more than one perforation gastric resection should be carried out.

Dr R M Pool, Fairfield, Ala. At the Employees' Hospital at Fairfield, where Dr Lloyd Noland is my chief, we have observed 50 perforated peptic ulcers during the past eight years. In this group of 50 cases, two had reperforations. At the operation for second perforation a simple closure was done and we have not heard from these since. An interesting thing is the interval between the first and second perforations, one occurred in about a year at the site of the previous ulcer, and the other after about 18 months.

Three cases of perforated peptic ulcer came to secondary operation. In this group of three, a simple posterior gastro-enterostomy was done. We realize that gastro-enterostomy has certain limitations but we felt in these cases that it was the operation of choice because of pyloric obstruction with gastric retention and because of involvement of the head of the pancreas.

In our series of 50 cases there were seven deaths. We thought this was rather high, but after seeing Doctor Estes' figures we find it is not so high. Out of the seven deaths we would like to eliminate three from the statistics. One was a white woman, age 78, who was admitted three days after perforation in very poor condition, and who died without operation. The clinical diagnosis in this case was perforation of the stomach due to malignancy, but postmortem examination showed a perforated, benign duodenal ulcer, with peritonitis. Another patient died on the operating table and we considered that an anesthetic death. The third, who also died on the operating table, was practically moribund at the time of admission and should probably not have been subjected to surgery.

Dr W L Estes, Jr, Bethlehem, Pa (closing). The large perforations are more likely to be attended by shock, more likely to be followed by rapid fulminating peritonitis, and require especially prompt operative interference. In these cases the problem of adequate closure may be more difficult to meet. The method of closure of the perforation is always of interest. Doctor Finney spoke of his very ingenious method and the end-results. I think most of us are familiar with the method suggested by Roscoe Graham, of simply taking a free bit of omental graft and suturing it over the opening, this simple procedure was employed in the series in which his very low postoperative mortality was obtained. Whatever technic is used, it is important that the closure be tight and complete and that an adequate lumen of the duodenum be preserved. In the type of closure we described I want to emphasize two things. The purse-string suture should not be tied too tight, the infolding sutures can be taken at quite a distance from the perforation. Even with large infolding there is little danger of stenosis.

There should never be any delay in operation in order to obtain a radiograph to prove the presence of pneumoperitoneum, with a clear-cut clinical syndrome immediate operation is demanded with no time out for unnecessary diagnostic refinement

Reperforation occurred in our series as early as six weeks following the first perforation, and as late as four years. Three cases reperforated two years after the original perforation with no premonitory symptoms of any sort. Reperforation unquestionably is of more frequent occurrence than it has been hitherto statistically indicated. Perforation does not necessarily confer immunity from further ulcer development nor alter the "ulcer diathesis." Therefore, ulcer cases after perforation should have the same careful persistent medical supervision that any peptic ulcer case demands.

CARCINOMA OF THE DUODENUM*

REPORT OF TWO CASES IN SUPRAPAPILLARY PORTION

ISIDORE COHN, M D

NEW ORLEANS, LA

THIS REPORT is based on two cases of carcinoma of the suprapapillary portion of the duodenum. A correct preoperative diagnosis was made in both instances. It should be stated, however, that the diagnosis was largely based upon the roentgenologic findings.

Case 1—C M, white, female, age 71, married, was admitted to Charity Hospital of New Orleans, January 31, 1942, complaining of "a lump in the stomach."

Two years prior to admission she began to vomit, and stated that the vomiting was associated with headaches. About one month prior to admission, she noted a mass in the epigastrium just to the right of the midline. She would vomit from time to time, but the vomiting was not associated with nausea. She complained of pain in the upper right quadrant of the abdomen. There had been a weight loss of from 20 to 30 pounds during the previous two months. The bowel habits had been regular and at no time had she tarry stools.

In briefly summarizing the findings only the essential facts in connection with the examination which have to do with the abdominal findings will be given.

The abdomen was soft, slightly rounded. The veins were not prominent. There was tenderness in the epigastrium and to the right of it. To the right of the midline in the epigastrium a movable, tender, hard, irregular mass was palpable. The liver and spleen were not palpable. Stools were negative for blood, parasites, and pus. Gastric analysis: Occult blood, no free hydrochloric acid, total acidity of 6.

Roentgenologic Examination—G I tract, No 655332 February 3, 1942. "There is a constant defect in the distal portion of the stomach and proximal portion of the duodenum. At the end of six hours, there is 40 per cent gastric retention. The findings are compatible with carcinoma of the stomach or pancreas."

A review of the roentgenograms which suggested the diagnosis of carcinoma of the duodenum revealed the following: 1. The first portion of the duodenum was dilated, and even after the barium had passed into the small intestines, there was evidence of some retention of the barium on a changed mucous pattern of the duodenum. It seemed that this could only be due to a fungus-like growth or possibly a polypus within the duodenum around which the barium remained adherent. We felt inclined to the diagnosis of carcinoma of the duodenum and the operative findings proved the correctness of the assumption.

Operation—February 11, 1942. *Preoperative Diagnosis*: Carcinoma of the duodenum in the suprapapillary portion.

Summary of Operation—A right paramedian incision was made from the costal margin to just below the level of the umbilicus, no free peritoneal fluid was encountered.

A firm mass, about 5.5 cm in diameter, was found in the first portion of the duodenum, just distal to the pylorus. The liver was inspected and palpated, and no evidence of metastases were found. Some nodules were found in the great omentum close to the greater curvature of the stomach. The head of the pancreas was intimately adherent to the involved portion of the duodenum, and was apparently involved in the disease. We

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CARCINOMA OF DUODENUM



FIG 1—Roentgenogram showing mucosal pattern changes in the duodenum

were able to mobilize the duodenum and section it below the growth. The distal stump of the duodenum was closed with tier sutures, after the Parker-Kerr technic. Resection of the stomach and duodenum was proceeded with, followed by a retrocolic anastomosis, between the stomach and the jejunum. The abdomen was closed with tier sutures. The operative procedure was carried out under my supervision by the Resident in Surgery at Charity Hospital, Doctor D₁ Leo.

The patient recovered and left the hospital March 13, 1942.

Pathologic Report—Clinical Diagnosis Carcinoma of the duodenum with nodal metastasis (M1634 S-42-1040)

"Gross" The specimen consists of the distal 13 cm of the stomach and the proximal 7 cm of the duodenum. The stomach appears normal except for a recent hemorrhagic mucosal ulceration measuring 1.5 cm in diameter which is located 6 cm from the pylorus. There is a rounded pedunculated mass located in the duodenum immediately beyond the pyloric ring, which measures 5 × 4 cm and whose base to apex measurement is 2.5 cm. The diameter through the pedicle measures about 3.5 cm. The surface of the mass is somewhat irregular. The tissue is gray and granular and is quite friable. Along the greater curvature of the stomach near the pylorus there is a group of enlarged lymph nodes, which measures about 5 × 3 × 1.5 cm. On cut-section, these lymph nodes

show a complete loss of architecture, the tissue having been replaced by a homogeneous, gray, granular, somewhat friable tissue

Microscopic The tissue is composed of an infiltrating epithelial neoplasm which is arranged for the most part in solid cords and large sheets of cells. Some of the cords are only one or two cells in thickness. In a few areas there is definite evidence of acinus formation. The individual cells are quite large and contain an abundance of basophilic granular cytoplasm. The nuclei are rounded and contain one or more large nucleoli. Mitotic figures are not infrequently seen. The stroma is not abundant but is sufficient in quantity to separate the neoplasm in the masses previously described. Foci of inflamma-



FIG. 2—Roentgenogram showing mucosal pattern changes

tory cell infiltration are present throughout the neoplastic tissue. These consist largely of plasma cells. The enlarged lymph nodes show neoplastic tissue similar to that which was seen in the duodenum. *Pathologic Diagnosis*: Adenocarcinoma of the duodenum, with metastases to the regional lymph nodes" (Schenken).

The patient was readmitted to the hospital April 27, 1942, and died May 18, 1942.

Case 2—T. R., white, male, age 64, was admitted to the hospital May 27, 1943, complaining of abdominal pain which he attributed to "liver trouble." He had previously had gastric disturbances which he had been told was due to "gallbladder trouble." At one time he reported that he had had some tarry stools.

Patient was obese. Skin was dry and scaly. There was no jaundice. Abdomen was symmetrically enlarged, there were no scars. Neither the liver nor the spleen were palpably enlarged. He did complain of pain on deep palpation in the right hypochondrium and along the course of the sigmoid.

A barium enema showed no evidence of disease of the colon. Gallbladder visualization was negative. G. I. series indicated "Deformity of the duodenum, which suggests the possibility of an excavated ulcer." On the basis of this report the possibility of carcinoma of the duodenum was considered.

Since there was no evidence of jaundice it was our impression that if carcinoma of

CARCINOMA OF DUODENUM

the duodenum did exist, it must be suprapapillary. The patient was admitted to Touro Infirmary with a view of operating, and if possible of performing a radical resection. Further roentgenologic studies showed "The stomach is of the 'J' type and lies high in the abdomen. The impression is obtained that the gastric walls are smooth and flexible and that peristalsis passes without interruption to the pylorus. No gross organic lesion can be demonstrated in the stomach. The duodenal bulb fills immediately and its contour is smooth and regular. *In the descending segment of the distal duodenum, just above the ampulla of Vater, there is a sharply demarcated, large, oval filling defect, measuring 4 x 3 cm in the greatest projected diameter.* The mass which produces it, apparently arises



FIG. 3—Gross appearance of lesion

from, or deeply impresses, the lateral wall of the duodenum, the thin contrast stream outlining the medial border of the abnormal mass.

"The findings are suggestive of an intraluminal neoplasm, possibly benign. An ectopic pancreatic lobule (annular pancreas), might well produce the same deformity. The distal duodenum is normal. In six hours the stomach and duodenum are empty, the barium being distributed through the lower small intestine and proximal colon" (Teitlebaum).

Laboratory Data—Red count 3,650,000. Total white count 8,250, neutrophils 68 per cent, eosinophils 2 per cent, lymphocytes 28 per cent, monocytes 2 per cent. Blood chemistry: Calcium 10.2 mg, phosphorus 2.88 mg, dextrose 87 mg, NPN 30. Metabolism: Plus 6 to plus 1. Electrocardiographic findings were reported within normal limits.

Operation—June 2, 1943. *Preoperative Diagnosis*: Carcinoma of the duodenum.

Under nupercaine spinal anesthesia, a long paramedian incision was made on the left side. The stomach was small and we were able to completely exteriorize it. The pylorus was easily identified and seemed perfectly normal. About two inches beyond the pylorus, and on the medial aspect of the duodenum, there was a thick infiltrated mass which was probably an inch and one-half long, easily palpable but not movable. The gallbladder was not adherent to the duodenum. It did not seem feasible to undertake a resection of the stomach and duodenum. The great amount of fat in the mesocolon obscured vascular markings. An anterior gastro-enterostomy was done. It was realized that this was only

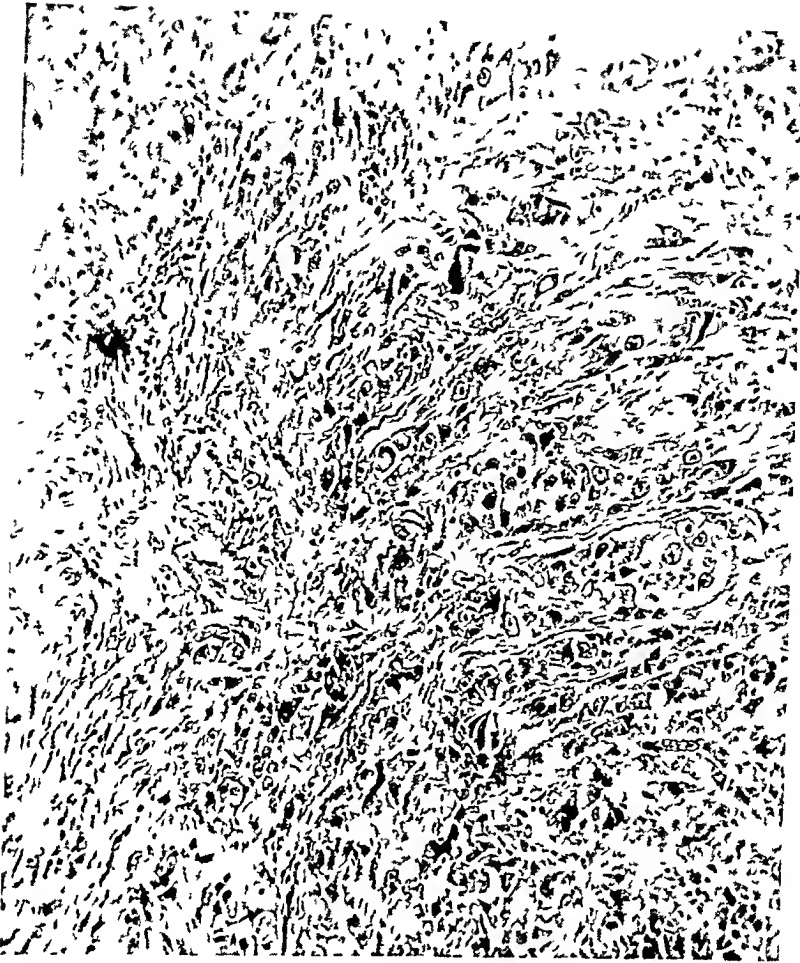


FIG 4—Microphotograph (see description in pathologist's report)

a palliative operation, but we felt that any attempt to be radical might result in a tragedy. The abdomen was closed.

Following the operation the patient persisted in vomiting and, on June 16, he was reoperated because of a vicious circle following the gastro-enterostomy. At this time, we found that he had an intestinal obstruction due to adhesions, an entero-anastomosis was done. The patient improved for a few days, but later developed a lower obstruction and, in spite of every effort, expired on July 7.

Much of the enthusiasm which I experienced because of a correct diagnosis, was dampened because of the failure of our efforts to accomplish anything for the patient. Investigation of the literature does not do a great deal to warrant optimism in regard to carcinoma of the duodenum, particularly, of the suprapapillary portion.

It is admitted that carcinoma of the duodenum is a rare disease. Compiled statistics indicate that (1) It is found in 0.03 per cent of all carcinomas. (2) Carcinoma of the duodenum constitutes 0.3 per cent of all cancers involving the intestines. (3) One-half of the carcinomas of the small intestines are to be found in the duodenum.

It will not be my purpose to compile statistics, nor will I review the various



FIG 5—Mr T R Note change in mucosal pattern of duodenum

theories which had been advanced. A large number of articles have dealt exhaustively with the subject of carcinoma of the duodenum. During recent years Hoffman and Pack, Stewart and Lieber, and Duff, Foster, and Bryan, have capably presented the subject.

The diagnosis of carcinoma of the duodenum preoperatively, according to the literature, has been made only infrequently. This is depressing in spite of the fact, that a rather careful, clear, clinical picture has been recorded for nearly half a century. Throughout the literature one finds such statements as "Until recently the diagnosis has been rarely made during life or before operation, and even with the aid of roentgenology, it is often very difficult to recognize the disease."

The insidious character of the disease and the gradual development of an obstruction, with symptoms common to those of carcinoma of the pylorus, with obstruction, may exist for a period of from six months to four years, without a correct diagnosis being made.

Great progress has been made as a result of the use of roentgenology and



FIG 6—Mr T R Note change in mucosal pattern of duodenum

gastrosopic methods in intrinsic lesions of the stomach and other portions of the bowel, but apparently similar positive progress has not been made in conjunction with carcinoma of the suprapapillary portion of the duodenum. Thus, Stewart and Lieber state "Roentgenographic studies are of little direct value in making a positive diagnosis of carcinoma of the suprapapillary portion of the duodenum." These same authors do not think it is possible to distinguish defects in the suprapapillary segment due to carcinoma from deformities due to ulcer.

Hoffman and Pack, in 1937, concluded that "A diagnosis of cancer of the duodenum is attended with so much difficulty that most of the recorded cases are recognized only at operation or at autopsy" and further state "In only a few cases reported in the literature has the condition even been suspected. Because of its rarity it is usually not even considered as a possibility in a differential diagnosis. If the possibility of carcinoma is given consideration,

it should be feasible to make a presumptive diagnosis in certain of these cases " Relative to the roentgenologic findings they conclude that they "are usually interpreted as deformities and contractures due to duodenal ulcer "

A review of the literature and a summary of the experience induces a very discouraging picture. Unfortunately, the signs and symptoms on which, up to the present time, even a suspicion of the real nature of the lesion are, in reality, the manifestations of an obstructive stage of the disease. This is of necessity, a very late stage and one in which hope for anything like good end-results, so far as cure or prolongation of life are concerned, are extremely bad.

CONCLUSIONS

1 One cannot help but be impressed with the insidious character of carcinoma of the duodenum, particularly the suprapapillary type, as these cases are not associated with jaundice.

2 The almost asymptomatic course of the disease until it becomes obstructive in character is important.

3 The absence of pain until the late stage of the disease, seems to be an outstanding characteristic.

4 In spite of the fact that so many insist that roentgenologic manifestations are not of diagnostic value, I do not believe that anyone could doubt for a moment the importance which should be attached to such mucosal pattern changes as were noted in the cases which are herewith presented.

5 Unfortunately, the extensive nature of the disease which was found in one of our cases, made it impossible to do more than palliative procedures. In the other instance, it was possible to perform a resection of the stomach and portion of the head of the pancreas and duodenum, followed by a Pólya-type of operation, but this only prolonged the patient's life for a period of two or three months.

6 The importance of being conscious of the possibility of carcinoma of the first portion of the duodenum, cannot be overestimated if eventually our results from a surgical standpoint, are to be improved.

7 Since the differentiation between ulcers of the duodenum and carcinoma of the duodenum is so difficult to make, it becomes necessary to revise our attitude in regard to some duodenal ulcers in individuals past middle life.

8 If carcinoma of the duodenum is to be cured operation must be undertaken before the obstructive stage, which, in reality, is an antemortem manifestation. Such an admission is a sad confession of one's shortcomings.

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DISCUSSION—DR DERYL HART, Durham, N C In view of the rarity of carcinoma of the duodenum as distinct from carcinomas of the head of the pancreas and the ampulla of Vater, I want to call attention to the possibility of aberrant pancreatic tissue being confused with carcinoma both in the roentgenograms and at the operation

I have seen a number of patients with aberrant pancreas in the wall of the duodenum, and would like to call attention to two recent instances The first had an annular mass of pancreas surrounding the duodenum, and was asymptomatic until a relatively mild attack of pancreatitis caused sufficient swelling to produce partial duodenal obstruction At the time of operation the presence of the pancreatitis was an aid in making the diagnosis The obstruction was relieved by an anterior gastro-enterostomy

The second patient presented much greater difficulties in diagnosis In a man of advancing years, with a progressively increasing obstructive jaundice (van den Bergh test (direct), bilirubin 29.4 mg per 100 cc before operation) roentgenograms of the barium-filled duodenum revealed a filling defect at a point interpreted as the region of the ampulla of Vater A diagnosis of carcinoma of the ampulla of Vater was made and operation was performed, with the object of resecting the tumor with a portion of the duodenum At operation, the first indication of an error in diagnosis was the presence of a nondistended gallbladder, further examination revealed a small common duct On palpation, a mass, measuring $1 \times 1.5 \times 2$ cm, was felt in the duodenum in the region of the ampulla, as had been demonstrated roentgenologically The duodenum was opened, the lesion had the appearance of the ampulla of Vater with malignant change and an ulceration of 5-8 mm in diameter However, the ampulla was located about 1.5 cm from this mass The portion of the mass protruding into the duodenum with the ulceration was excised, and microscopic study revealed normal pancreas, with an ulcer overlying the point of maximal protrusion into the duodenum The duodenum was closed, the patient developed signs of liver insufficiency, and died four days after operation

Such conditions require that we keep in mind the possibility of benign lesions being confused with carcinoma, with resultant extensive resections carrying a relatively high risk

CONGENITAL PYLORIC STENOSIS^{*}

CHARLES A. VANCE, M D

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CONGENITAL PYLORIC STENOSIS is the most common condition that requires surgical treatment in the first few weeks of life. The baby with this condition has an increase in size of the pyloric muscle, so that the lumen is compressed and obstructed and there are signs of high intestinal obstruction.

The mortality in this condition varied from 50 to 75 per cent prior to 1908. Today, proper surgical technic combined with good preoperative and postoperative care has reduced the mortality in competent hands from 1 to 2 per cent.

Fredet, in 1908, devised and performed something like the operation finally developed by Rammstedt in 1912. This has been aptly named "pyloromyotomy," or the Fredet-Weber-Rammstedt operation, or the Rammstedt operation. Fredet performed his first operation October 12, 1907, by carrying his longitudinal incision only as far as the submucosa, leaving the stomach unopened. He then sutured the muscle transversely. In September, 1911, Rammstedt operated following Fredet's and C. Weber's operation, which was similar, and was impressed by the ease by which the edges of the wound in the muscular wall of the pylorus gaped and the submucosa bulged. The patient continued to vomit for a few days and suddenly ceased and thereafter made an excellent recovery. He remembered that the muscle edges had been tight and closed under tension and that the sutures must have given way and the wound righted its direction, allowing the edges to separate and the mucosa to protrude and thus the obstruction was overcome, so, on January 18, 1912, he tried this idea and the patient recovered without incident. The same year he reported his two operative cases, setting forth very clearly his method and advocating the technic as best suited to deal with the problem of congenital pyloric stenosis. Rammstedt advocated the use of the term "pylorotomy," but it has generally become known as the Rammstedt operation, or "pyloromyotomy." Infantile pyloric stenosis seems to me the best name for the condition.

The scattered accounts of cases closely corresponding to congenital pyloric stenosis were published as early as the seventeenth century and the case of Hildanus, a famous German pediatrician, seems to be the first, in 1646. Blau discussed a case in 1717, C. Weber, in 1758, and Armstrong, in 1777, described a typical case in an "Account of Diseases Incident to Children from their Birth to the Age of Puberty With the Successful Method of Treating them."

An infant had died of "watery gripes" at the age of three weeks, Armstrong notes. "The extremities felt very cold, except when kept warm by art."

^{*} Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

The face, likewise, felt cold and looked very pale, pinched and distressed" The pathologic picture is set forth in considerable detail Most of the stomach, including the whole of the fundus, was in a "tender state," as if "the coats had been reduced by maceration to almost gelatinous consistence," but toward the pylorus the stomach structure was "firm enough" The stomach was quite distended with curdled milk and victuals with which the nurse had crammed the child, but the whole intestines were remarkably empty" From these findings Armstrong attempts to find an explanation of the condition "There was no morbid appearance to be observed anywhere but in the stomach and this viscus being so full while the intestines were almost empty, it looked as if the disease had been chiefly owing to a spasm in the pylorus which prevented the contents of the stomach from passing into the duodenum" He comments that "Perhaps cases of this kind are more frequent than is commonly imagined," and adds "What is remarkable, this was the third child (and they never have had any more) which the parents have lost at the same age, and with the same disease"

The first case of pyloric stenosis reported in this country is credited to Hezekiah Beardsley, who, in 1788, presented a "Case of Scirrhus in Pylorus of an Infant" before the Medical Society of New Haven It appeared in 1788, in the first Medical Periodical published in the United States It was discovered and made public again by Sir William Osler, and for many years it was believed to be the earliest example of the disease then extant In the early nineteenth century Pauli (1839) and Williamson (1841) made accurate independent observations of this condition, and Dawosky (1842) for the first time described the projectile character of the vomiting

In 1887, at the Wiesbaden meeting of the Gesellschaft für Kinderheilkunde, Hirschsprung described two cases of congenital pyloric stenosis He gave an excellent account of the gross pathologic changes and expressed the supposition that these alterations were the cause of the definite clinical form of infantile vomiting Within a brief time after Hirschsprung's presentation the disease became widely known

I have reviewed the transactions of the Southern Surgical Association on this subject

First, there is a paper by Dr G C Gavin, of Mobile, Alabama, presented at the Twenty-fourth Annual Meeting, held at Washington, D C, in 1911 He gives a very interesting discussion and report of a case, male, age seven weeks It was diagnosed and he operated upon it, performing a gastro-enterostomy in September, 1911 He had good illustrations and drawings of the case The patient made a good recovery

Next was a paper by Dr James F Mitchell, of Washington, read at the Atlanta Meeting, in 1913 He opens his paper by saying "On first thought, it would seem that an apology is due the association for presenting such a well-worn subject" He gives a most interesting discussion about the theory of the etiology of the disease and has a number of good illustrations of the cases He reports three cases A gastro-enterostomy was performed on each

one of them, and all of the patients recovered. He mentions Rammstedt's operation in his paper but did not employ it on these three cases. Doctor Mitchell says "Dr. Dean Lewis, of Chicago, had four successful cases." The paper was discussed by Dr. Charles Mixter, Jr., of Boston, and Dr. C. Coffey, of Portland, Oregon. Both gave very interesting discussions. Doctor Coffey greatly laments the fact that the cases were not brought to the surgeon soon enough and that the medical men should be given further education, and Doctor Mitchell finishes his paper by saying "That the chances for the recovery of these patients depends on getting them to the surgeon early."

Next was a paper by Dr. William A. Downes, of New York, read at the Cincinnati Meeting in 1915. He first reported in April, 1914, 22 cases, and in 1915, 44 additional cases—66 personal cases in five and one-half years. He gives a very full and complete discussion of the cases, the symptoms, and causes of death. His cardinal symptoms were Projectile vomiting, tumor, peristaltic waves, gastric distention, rapid loss of weight, and marked constipation. Nearly half of these 66 cases had a gastro-enterostomy. He first incised the circular muscle, after the Rammstedt method, in October, 1914. In 19 cases he first employed the Rammstedt procedure, after which he made a small opening in the anterior wall of the stomach and passed a sound into the stomach and through the pylorus, making sure that the pylorus was patent, but he decided that these cases did no better than the ones in whom a gastro-enterostomy had been performed, so he quit that and employed the Rammstedt procedure in the last 34 cases. His mortality in the 66 cases was about 23 per cent. Of course, many of his cases were moribund when they were admitted. The preoperative preparation was not emphasized. He advocated beginning the incision at the stomach end and mentioned the dangers of getting into the duodenum. In his conclusions he brings out the advantages of the old operation and the new Rammstedt procedure. The gastro-enterostomy is more difficult and takes longer to perform. The Rammstedt procedure is simple, easy and requires less surgical skill and the obstruction is permanently removed and the normal continuity of the intestine throughout is preserved, that the method is open to criticism in that it leaves an uncovered wound, and the abdominal cavity is protected from contamination only by a thin layer of mucous membrane, and as the scar contracts the obstruction will reform, and he recommends that a gastro-enterostomy be performed if in any case there is reason to suspect that the lumen of the pylorus does not become patent after division of the circular muscle, and he says "That continued experience and longer observation of the cases may bring out more serious objections to partial pyloroplasty, but until some better method is proposed the method according to Rammstedt should be the one of choice." "The success or failure of the operative procedure is determined in a large measure by the length of time elapsing between the onset of symptoms and the time of operation."

Next, at the Fortieth Annual Meeting at Augusta, Georgia in 1927, a paper on "Congenital Pyloric Stenosis" was read by Dr. J. M. Mason, of

Birmingham, Alabama He gives a most excellent presentation of the subject He reviews the literature before that time and pays tribute to Dr William A Downes, whom I have quoted above He quotes from Wollstein "That the wound in the pylorus is healed within nine days The pylorus has returned to normal size within a month The gap between the cut ends of the muscle has practically disappeared in six weeks In two years only a thin line of connective tissue fibers separates the two muscle ends and the stomach is quite normal Thus, in contrast to gastro-enterostomy, which leaves the pylorus unchanged, the Rammstedt operation cures the pyloric lesion" He contrasts the difference between the medical and surgical treatment and recommends that all cases should be sent to the surgeon and operated upon, and he emphasizes the preoperative and postoperative care He believes in suturing omentum over the pyloric wound He gives a most excellent description of the operation and incident dangers, and reports 25 cases, seven of which he personally operated upon

There has been no mention of congenital pyloric stenosis in the Transactions of this Association since Doctor Mason's paper, in 1927 The whole history of congenital pyloric stenosis is covered by these papers which are in the records of this Association, and I feel that we, as Fellows, should be very proud of all of these men who have done this most excellent pioneer work

Another paper which I reviewed on congenital pyloric stenosis was published in February, 1931, in the Tennessee Journal of the State Medical Association, and was written by our distinguished friend, and president of the Association, Dr Barney Brooks He gives a most interesting and exhaustive presentation, with report of ten cases, and many practical points in the diagnosis and treatment His experience covered the period of his connection with the St Louis Children's Hospital, and the Vanderbilt University Hospital He says "that in the early period gastro-enterostomy was accepted as the operation of choice"

The sign, which in his opinion, far outweighs in importance any point in the clinical history or any physical sign, is the ability to palpate in the region of the pylorus a small, firm, hard tumor He believes this sign to be essential in making the diagnosis of congenital pyloric stenosis He then says, "the ability to palpate this tumor must be a sort of 'knack' because he has frequently been able to feel this tumor and at the same time he has not been able to demonstrate its presence to any of his assistants" The method he found useful is as follows "Give the child a bottle at the same time the examining hand is resting upon the infant's abdomen During the very brief time in which the child first takes the bottle, the abdomen may be sufficiently relaxed to feel the pyloric tumor Any one having once felt the tumor characteristic of congenital pyloric stenosis can never fail to recognize it again, even if the fingers touch it for only a fraction of a second"

He believes that the examination of the gastro-intestinal tract by means of a barium meal and roentgenology is of value only when its limitations are appreciated If barium is put into the stomach and some of it is seen to pass

readily into the duodenum, pyloric obstruction is obviously not present. In a great many instances it has been found that the barium failed to pass into the duodenum in instances of infants without congenital hypertrophic pyloric stenosis. These instances were those in which the barium was vomited very soon after being taken, or were the result of true pylorospasm. He is inclined to believe that roentgenologic examination with the barium meal may be very good evidence against the existence of a congenital hypertrophic pyloric stenosis, but that it could never be conclusive evidence of its presence. In a statement he recently made to me he says "Unless the case is clinically certain always give the child a little barium and examine fluoroscopically. Only last week this procedure kept me from operating upon a first born male who was vomiting and who had a palpable tumor in what I thought was the right place. The fluoroscope showed the pylorus wide open and the palpable tumor, a lymph node, I suppose, quite separate from the duodenum." He believes in the use of local anesthesia for the operation, and makes his incision just above the liver edge. "The liver then acts as a perfect stopper and the baby can not eviscerate, no matter how hard he strains." He believes that the pyloric tumor should always be divided from left to right, and uses the handle of his knife as a chisel rather than the cutting edge. In his recent communication he says "that he has done now well over 100 cases without a death and often takes two or three days getting the baby ready."

I feel that these papers of Doctors Gavin, Mitchell, Downes, Mason and Brooks on this subject are outstanding contributions, and I am sure all of you Fellows present will agree with me.

Etiology—The cause of congenital pyloric stenosis is not understood. There are a number of theories which attempt to explain it. It seems to me that three factors enter into its formation. Congenital hypertrophy of the pyloric muscle, spasm, which may be secondary to the congenital hypertrophy, and an added compensatory or work hypertrophy. As far as I am concerned, the etiology of this condition is far overshadowed by practical consideration of the surgical treatment. It affects male children predominantly, in a ratio of about nine or ten to one. There seems to be a preference for first born babies who are robust and above the average weight at birth. From the published cases it would appear that the parents are most often young, healthy and in favorable economic circumstances. Familial occurrence, noted by Armstrong in 1777, has been frequently mentioned in later reports. Three cases of pyloric stenosis in the family of five children has been seen. The occurrence of pyloric stenosis in parent and offspring has been observed more rarely.

Pathology—The pathologic findings are hypertrophy of the circular pyloric muscle, and an actual increase in the number of smooth muscle fibers. This produces an olive-sized, bulbous or fusiform mass which has a smooth external surface. It seems almost as hard as cartilage. The lumen of the stomach is gradually reduced in size toward the pylorus but the lumen of the duodenum assumes its full size at once, due to the abrupt termination of the pyloric sphincter at its distal end.

Symptoms—The symptoms of all cases are those of high obstruction and severe loss of body fluids. Doctor Ladd says "that if the five cardinal symptoms are present, namely, scanty stools, projectile vomiting, loss of weight and dehydration, visible peristalsis and palpable tumor, roentgenologic examination is not necessary nor desirable." The symptoms usually start within three weeks and the initial symptom is vomiting, which is projectile in character and seldom occurs before the ninth or tenth day after birth and usually before the child is 12 weeks old. At first, the vomiting may be little more than just regurgitation but soon it becomes more forceful and projectile in type. The vomitus does not contain bile but only gastric contents. Each feeding may be returned immediately but if the stomach is dilated several feedings may return together. Since little of the food really passes the pylorus there is constipation. Diarrhea sometimes occurs as the result of infection or starvation and the passage of accumulated intestinal juices. The child is continually hungry because so little food passes into the intestines to be absorbed. Therefore, he will eagerly nurse or take the bottle. Loss of weight is rapid. According to the degree of stomach peristalsis, waves are visible passing from left to right. These should be looked for immediately after feeding while the stomach is under maximum stimulus to overcome the obstruction.

The pathognomonic symptom which makes certain the diagnosis of congenital pyloric stenosis is the presence of a palpable tumor in the right upper quadrant, a little above the level of the umbilicus at the outer border of the right rectus muscle. One observer has found its location by watching for the point where the peristaltic wave ends. But the stomach should be empty for palpating this mass which is olive-shaped and indurated. Doctor Ladd says "the pyloric tumor has been felt in 95 per cent of all his cases. The amount of fecal residue is decreased as the pyloric obstruction is increased, therefore, the stools become less frequent and scant. With continued starvation, failure to gain weight or loss of weight always occurs. Dehydration is evidenced by wrinkles appearing in the skin anywhere on the body. He looks just like a little old man."

Physical Findings—Examination of the abdomen is of the utmost importance. There may be some distention in the area of the stomach and palpation may show a distended stomach if the baby has recently nursed. Gastric peristaltic waves can be seen passing from left to the right. Palpation of the right upper quadrant with tips of the fingers will reveal, in most cases, the pyloric tumor.

Roentgenologic Examination—Roentgenologic examination is not always necessary. There are, however, a few cases in which the history is atypical, or the physical examination is unsatisfactory, and whenever the diagnosis is in doubt it is best to obtain additional information by roentgenologic examination. A film of the abdomen without barium will often show a large, dilated, gas-filled stomach, with relatively little gas in the intestine beyond the pylorus. If this is not satisfactory, a routine gastro-intestinal examination may be

done with a little barium introduced in the milk formula or given in a little water, which will demonstrate an enlarged stomach with a rounded pylorus and shows a ballooning forward and to the right, and greatly increase peristaltic activity and the passage of little or no barium into the duodenum. Films taken later will indicate how much retention is present, and a retention of a large portion of the barium at this time shows a pyloric obstruction.

Preoperative Care —Administration of parenteral fluids is the most important factor in improving the condition of these dehydrated patients. Fluids should be administered night and morning of each preoperative day. Intravenous 10 per cent dextrose in sterile water and salt solution by hypodermoclysis and blood transfusions are of great help. For the poorer risks oral feeding should be continued with the preoperative care. Vitamin C has been given by some of the observers.

Operative Procedure —Operation for congenital pyloric stenosis is not an emergency procedure, and a baby destined to surgery should be prepared for operation by the medical regimen outlined above. Generally speaking, the worse the infant's condition, the earlier one should attempt operative relief, but plenty of time should still be taken to get the baby in as good condition as possible.

Ether is administered by the drop open cone or mask method. I have used this method in all of the cases I have operated upon and have found it very satisfactory. In my experience babies have taken ether better than any other anesthetic, so I have continued to use it in all cases.

For skin preparation I usually wash with soap and water followed by ether and a weak solution of iodine. If the stomach seems to contain much fluid I sometimes pass a catheter through the nose and into the stomach and wash out with sterile water and leave the catheter in place during the operative procedure.

I make a high right rectus incision beginning above the edge of the liver and extending down an inch and a half or two inches. When the abdomen is opened the right lobe of the liver is retracted upward and the pylorus is delivered into the wound and the tumor held between the thumb and index finger and a longitudinal incision is made over the tumor at its least vascular part until the mucosa is bulging. Then the back of the knife is used to complete the operation until the mucosa is bulging into the wound. Any bleeding can usually be controlled by moist pads. If that does not control the bleeding the vessels should be ligated with fine silk. If there is considerable bleeding a strip of muscle from the rectus may be sutured in the pyloric incision. It is most important to see that all bleeding is stopped before the abdominal wall incision is closed because death has been reported due to hemorrhage from the pyloric incision. The complication most to be dreaded is accidental opening of the duodenum. The change from thick pyloric tumor to thin duodenum is abrupt, so great care must be exercised in separating the cut edges of the muscle toward the duodenal end. I usually do not attempt to cover the pyloric defect with omentum or serosa. When I am satisfied about

the wound the pylorus is then dropped back into the abdomen. Then the wound is closed in layers. I use fine, chromic catgut making as few knots as possible, suturing the peritoneum and muscle and fascia using the same strand, and then close the skin with a few interrupted silk sutures. I have never used any abdominal wall incision but the one described. There is in use the gridiron incision, and several others, but I have had no experience with them. The head of the bed is lowered until the baby recovers from the anesthetic in order to prevent aspiration of mucus.

Postoperative Care—After pyloromyotomy for congenital pyloric stenosis gastric peristalsis is inhibited for several hours and is frequently depressed for longer than that. In average cases evacuation from the stomach through the pylorus of material ingested soon after operation does not begin until about eight hours and is not complete until 24 hours after operation, therefore, I do not believe in the early and frequent administration of water and food during the first postoperative day. Water is given sparingly at first and if the child is not vomiting at the end of 12 hours a suitable formula, or breast milk, is started and given every three hours. Most cases vomit a little for two or three days. Parenteral fluids are given in an adequate amount for the first two or three days and blood transfusions whenever necessary. At the end of two weeks, generous feedings are tolerated, the baby is gaining weight normally, and the wound has healed, and the skin sutures are out. The operation restores the stomach to normal and the child grows up to normal gastric functioning.

I have reviewed the case histories of 27 babies which I have operated upon since 1920. These were all private cases. I have used ether anesthesia, and have performed the Rammstedt pyloromyotomy through a high right rectus incision in every case. In most cases the baby was one to two months of age when it came to operation. There was one death. In this case there was no bleeding and no perforation of the duodenum. The patient seemed to be doing all right several hours after operation and suddenly he became worse and died. No autopsy was obtained. In the remaining 26 cases the operations were successful and the babies recovered. There were two females and 25 males. Nearly all of these cases were referred to me by one pediatrician, Dr. Thomas M. Marks, of Lexington, Kentucky. I have had the advantage of his assistance in the diagnosis and preoperative and postoperative care and I feel that the success obtained is largely due to him.

SUMMARY

Congenital pyloric stenosis is seen most often in male infants who were robust at birth. There is usually an interim of a few days or weeks during which the infant thrives. Symptoms start suddenly with vomiting which becomes projectile and is followed by constipation, loss of weight and exaggerated gastric peristalsis. Careful search will reveal a palpable mass, representing the hypertrophied pylorus, in most cases. The treatment of choice is Rammstedt's operation (pyloromyotomy). Preoperative treatment is most

important The results of operation are excellent in the great majority of cases Twenty-seven cases were briefly discussed

One writer sums up the whole situation when he says the criteria of success are threefold Early recognition of the pathology, prompt operation by an experienced surgeon, and careful postoperative management by a competent pediatrician Indeed, the pediatrician holds the key to the outcome of any case Brooks says in the long run the responsibility for the child's salvation rests upon him, for anyone who can even remotely be considered a surgeon can perform the operation successfully

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DISCUSSION—DR DERYL HART, Durham, N C I enjoyed Doctor Vance's presentation very much Most people agree that this condition is best treated surgically In a series of more than 60 patients so treated, over a period of 16 years, we have had no fatality, and in only a few cases has the duodenum been opened

These results depend on close cooperation between the pediatrician and the surgeon and a simplified technic, rather than on individual operative perfection, since many of the operations have been performed by the changing surgical residents Our technic differs only slightly from that of Doctor Vance All operations have been performed under local anesthesia through a high right rectus incision, lying predominantly over the liver The lower edge of the liver is retracted upward so the pyloric tumor can be delivered This is grasped between the thumb and index finger of the left hand, and a longitudinal incision is made in the anterior relatively avascular area, extending through the peritoneum and superficial muscles from the duodenum up onto the stomach above the tumor No further cutting is done, the remaining circular muscular fibers being broken across by tension This is accomplished by inserting the point of a hemostatic forceps between the edges of the peritoneal incision and spreading very slowly and carefully The instrument is held tangential rather than perpendicular to the pyloric tumor so as not to run any chance of the point perforating the lumen As the muscle fibers break, the submucosa is exposed and, with further spreading, it bulges up into the incision as the muscle retracts and separates from the submucosa

The advantages of this procedure in our hands is that no instrument ever touches the submucosa, the amount of tension can be accurately controlled, and the entire procedure is under visual control The only possible chance of entering the lumen is at the duodenal end, where too great tension can tear through the more delicate structures This muscular division should be carried down to, but not onto, the thin-walled duodenum After completing the division and controlling any bleeding, the raw surface may or may not be covered over by a free or pedicle graft of omentum The liver then is allowed to fall back in place to underlie the incision, thus giving some protection against evisceration The peritoneum is then closed with a continuous suture of catgut, or interrupted sutures of silk or cotton The remainder of the incision is closed in layers with interrupted sutures of fine silk or cotton Following such a closure, evisceration is extremely rare In the rare cases where the lumen has been entered, the opening has been closed and convalescence has been satisfactory The most amazing complication from this has been the delay in resumption of feedings in these already undernourished infants There is always, of course, the fear of leakage and the development of generalized peritonitis

DR JAMES M MASON, Birmingham, Ala This is a very interesting subject and I have been pleased with the manner in which it was presented As in all radical procedures, the surgeon cannot get very far until he has the hearty endorsement of his medical colleagues Going back into the history of the operative treatment of hypertrophic pyloric stenosis in children, we find that the Fredet-Rammstedt operation was first performed in 1911 William A Downes, a former member of this Association, became interested in it and had operated upon 22 cases by 1914 In 1917, Holt, the leading pediatrician of his day, gave the operation his hearty approval in a paper which appeared in the Journal of the American Medical Association in that year

Since that time the value of the operation has been definitely established, and the diagnostic signs and symptoms have become so well recognized that prolonged medical treatment is giving way to prompt surgical intervention At the Children's Hospital

CONGENITAL PYLORIC STENOSIS

the pediatricians no longer persist in prolonged administration of atropine, or resort to thick feedings in infants who come in with a history of projectile vomiting, peristaltic waves, and with roentgenologic findings of prolonged barium retention in the stomach. When these conditions obtain, the Rammstedt operation is undertaken without delay and results have been uniformly satisfactory. The tumor is always sought for and, with experience, one can usually find it. Operation is not withheld, however, if the tumor has not been found and if the other symptoms are present.

In spite of the employment of the best technic, perforation of the duodenum may occur. In my earlier operations I had two deaths from this cause. Occasionally, evisceration will take place when the right rectus incision is employed. A transverse incision is just as easily carried out and the danger from evisceration is greatly lessened.

DR ROBERT L RHODES, Augusta, Ga. I just want to add several remarks and report two particularly interesting cases. In the first place I want to emphasize that one should not be impressed by failure to find projectile vomiting. When a child has reached the stage of exhaustion he does not vomit, and often that is when you see him. The second thing is that you do not always have a mass that is easily palpable, as Doctor Vance brought out.

Recently I have seen two cases I want to record. Just a year ago a child was brought in, ten months of age, weighing five pounds. The diagnosis of pyloric stenosis had been made at the age of three or four weeks by the doctor who delivered the child, and he had advised operation. During the intervening time the parents had taken the child all over the State of Georgia looking for someone who would cure it without operation. Finally they returned to their own doctor, who sent them to me. There was no projectile vomiting, no palpable mass. We gave a little barium by way of confirmation, and if any portion of that half-ounce had passed through in 48 hours the roentgenogram failed to show it. After the usual preliminary building up with fluid, glucose and a little blood, we went in and found no pyloric muscle at all. A hair of your head would have represented the constricting band encircling that pylorus to the extent that you could not get to it, the stomach and duodenum bulging over the constriction. It was perfectly obvious that a Rammstedt operation could not be done, one could not reach the cicatricial band without opening the duodenum. So I decided that the best thing to do was a Horsley pyloroplasty. One could feel the knife as it nicked this band but could not see it even with the pylorus wide open. There was no evidence whatever of a pyloric muscle. The child made a good recovery, I am happy to say, and at the last report had gained 25 pounds since operation.

I had a typical case a couple of years ago in which the Rammstedt operation was attempted and, unfortunately, as Doctor Mason just said, we are going to nick the duodenal mucosa in spite of all precautions, and I immediately converted from the Rammstedt to the Horsley procedure and had no cause to regret it, since the result was excellent.

DR ROGER G DOUGHTY, Columbia, S. C. I have had the experience of getting into the duodenum, and in two instances we simply closed the pylorus and rolled over to a second avascular area and repeated the Rammstedt procedure at that point. It seemed to work very nicely, and it is a simple thing to do.

I was much interested in what Doctor Rhodes said about adhesions. Some years ago we reported a small group of cases of persistence of the anterior mesogastrium. I think this is a condition which has been confused with pyloric stenosis by pediatricians. There is one differentiating point, in pyloric stenosis they do not vomit bile, in persistence of the anterior mesogastrium they vomit bile early.

DR CHARLES A VANCE, Lexington, Ky. (closing) This subject was so interesting to me that I spent too much time with these five papers. In the written paper I have covered all the points brought out in discussion. Doctor Hart says he uses a spreader for the pyloric wound, others have used forceps or scissors. I saw one man operate who used too much force with Kelly forceps and spread the wound open from end-to-end into the stomach and duodenum. After that I quit using spreaders and have used the back of the knife and get just as good results, and I have not punctured into the duodenum and stomach. I was very much interested in hearing about Doctor Doughty's other incision. I had not heard of it being done before and shall remember it and use it when it becomes necessary.

NEUROFIBROMA OF THE SMALL INTESTINE*

REPORT OF CASE

JOSEPH D COLLINS, M D

PORTSMOUTH, VA

BENIGN NEOPLASMS of any kind are uncommon in the small intestine Rankin and Newell¹⁶ reported, in 1933, that they found only 35 cases in the files of the Mayo Clinic Morison,³⁰ in 1941, stated that he had studied material from 13,139 patients and only 21 benign tumors of the small bowel were discovered Heurtaux,² writing in the last years of the nineteenth century, could find but 29 authenticated cases in all previous medical literature Of the various types of small intestinal tumors the fibromata would appear to be among the rarest In Rankin and Newell's series only six fibromata were found Morison found only one fibroma in his studies While Heurtaux's list contains three fibromata, von Bruns,⁵ in his treatise on surgery, published at Stuttgart in 1913, notes that Heisig, reporting a case of fibroma of the small intestine upon which he had operated in 1897, had been able to find no similar instance in the literature

It is difficult from the early reports to decide which of the fibromata reported were of neurogenic origin Twentieth century pathologists have differentiated neurofibroma from fibroma in general, but in earlier cases details are so often lacking that it is not always possible to identify the type of fibroma that is being described Very probably the growths which formerly were called "fibroma" would today be designated by both clinician and pathologist as "neurofibroma"

Intestinal neurofibromatosis was recognized and described some years before the beginning of the present century In February, 1897, Albert Branca,¹ an intern working in Pierre Marie's clinic, published an account of one of Marie's cases, including an elaborate pathologic study The patient, an old alcoholic, was admitted to the hospital, well advanced in pulmonary tuberculosis The cutaneous surface was scattered over with typical lesions of von Recklinghausen's disease At autopsy the characteristic nerve lesions appeared in many of the internal organs, including the intestines

Branca concluded that although neurofibromata had previously been described only as appearing on the external body surface, precisely similar lesions might be produced in the intestines, given the proper conditions for proliferation A case clinically similar to Branca's was reported by Leriche¹ in 1911 The patient was tuberculous and manifestly suffering from von Recklinghausen's disease, but was operated upon because he showed clinical symptoms of a growth at the pylorus The operation disclosed a "fibroma without nerve elements undergoing sarcomatous degeneration," and the his-

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La

NEUROFIBROMA OF INTESTINE

tologic examination presented a picture similar to those later offered by twentieth century pathologists as "neurofibrosarcoma"

Since the recognition of neurofibroma as a separate entity, there has been no uniformity of opinion as to the etiology and origin of these rare growths of the small intestine King,⁶ in 1917, stated that it was his belief that the fibrous tissue of the nerve sheath is the probable site of origin, citing the cases reported by Leriche, Branca and Marie and Couvelaire³ All of these cases, however, were of generalized neurofibromatosis, with many intestinal

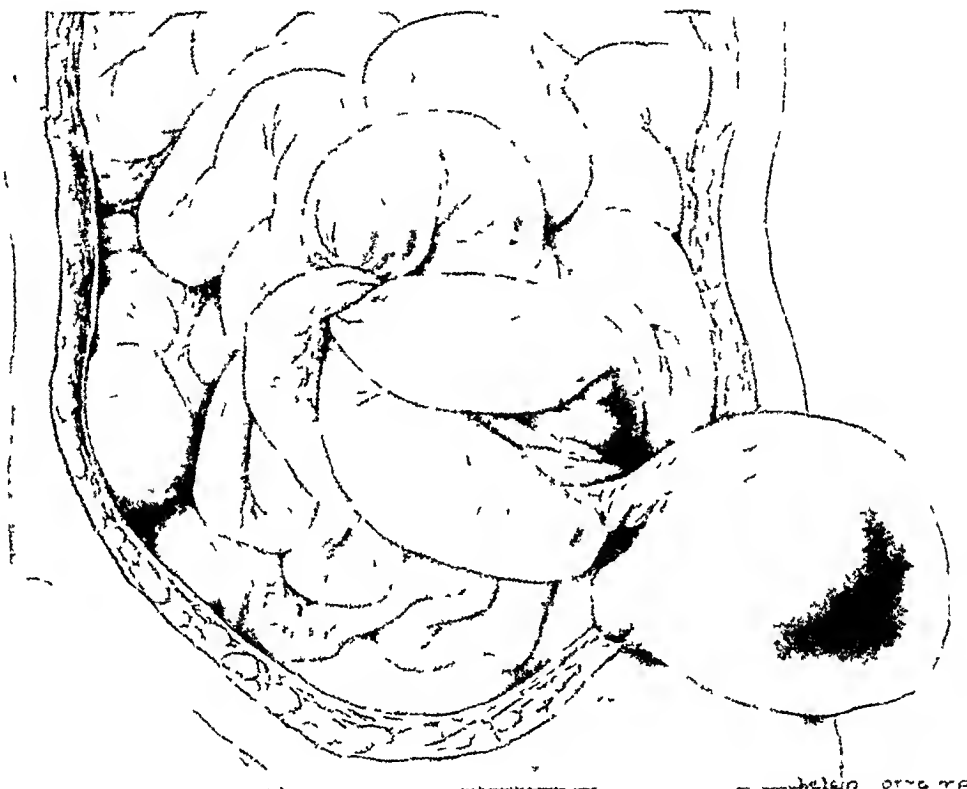


FIG 1—Sketch of operative findings showing the tumor twisted on its pedicle causing a volvulus

tumors, which can only be regarded as histologically identical with the cutaneous neurofibromata, with which the patients were known to be affected King adds that "an interesting point is that these tumors are frequently found in tuberculous subjects, also interesting is the fact that they are frequently associated with sarcoma"

The pathology of intestinal tumors arising in nerve elements seems to have advanced no further, either in continental Europe or North America during the decade which included the years of the first World War A perusal of the literature of this period shows that there was much uncertainty and confusion in the classification of these neoplasms In France they were variously termed "plexiform sarcoma" (Robert), "malignant leiomyoma" (Goulloud), "fusiform cell sarcoma" (Tedenat), "fibrosarcoma" (Bertrand of Montpellier), "fusiform sarcoma" (Goulloud), "fuso-sarcoma" (Walther) and "angiosarcoma" (Champy and Burty) An equal variety of designations

is to be found in American literature, and it may be added, an equal uncertainty in pathologic recognition

The study of gliomata arising in various parts of the nervous system, especially in those of the viscera, presented by Lhermitte and Leroux⁷ in 1923, cast some light upon the histology and etiology of these little understood neoplasia. They had been able to identify, in five cases, tumors situated in the wall of the digestive tract, the structure of which appeared in all respects to be identical with that of growths occurring in the peripheral nerves and in the spinal nerve roots. Four of these were at the pylorus or other parts of the wall of the gastric cavity, but one was "in the ileocecal region, and had developed in the thickness of the wall of the cecum, the mucosa of the intestine being normal."

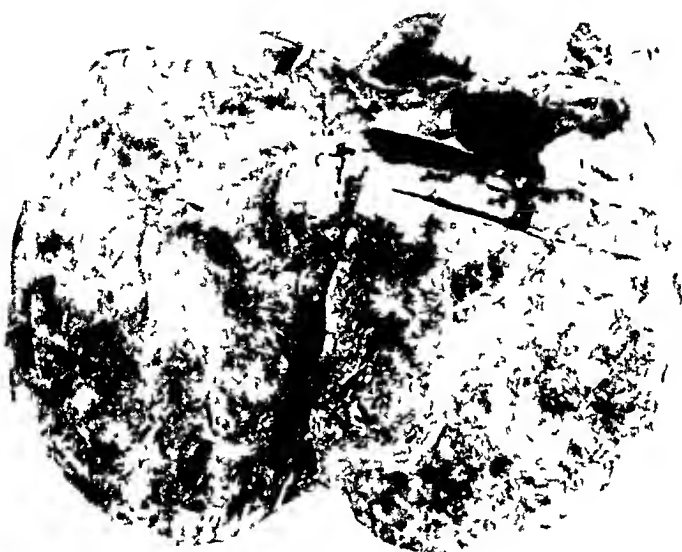


FIG 2—Photograph showing gross appearance of the interior of the tumor

In 1924, Gosset, Bertrand and Loewy⁸ published a paper in which they tabulated 66 cases of pedunculated tumors of the stomach, to which they added two cases of their own. The 66 cases had mostly been diagnosed as "malignant leiomyomas" or "sarcomas." They demonstrated by careful consideration of all pathologic material at their disposal (as described in the literature) that these growths were actually benign. Only six were assigned origins in nerve tissue and designated as gliomas, fibrogliomas or schwannomas. These neurogenic tumors were described as follows:

"A typical growth of the kind under discussion (that is pedicled tumors of the stomach) will prove under the microscope to have a structure identical with peripheral nerve tumors. Whorls of tissue appearing like connective tissue prove to be composed of fusiform cells, anastomosis between these whorls being very frequent. The structure of these whorls is very dense, and the individual whorls are often isolated in a stroma of connective tissue. This isolation of the whorls gives an appearance resembling cylindroma,

which is most often perceivable at the periphery of the growth, close to areas where degeneration is in progress. An appearance peculiarly characteristic of these growths is the nodule made up of cells in *palisade* formation, which is seen only in peripheral gliomas. Polycystic degeneration, at first limited to the protoplasmic zone near one of the nuclear poles of the individual cells, but later on forming large individual cysts, can be made out scattered through the entire structure of the growth. The elements deriving from the neurilemma (sheath of Schwann) do not proliferate by mitosis, but cleave longitudinally, so as to form a nodule with nuclei in line with the same axis. Because myxomatous degeneration is quite common, the swelling of the cell protoplasm, turning the cells into vesicles, so changes the appearance as viewed in the microscopic sections, that the growth is often mistaken for a connective tissue tumor, and its origin in the nerve sheath is wholly obscured."

These authors also cited a communication made by Paul Picquet, in 1922, to the Societe de Chirurgie, which was an anatomicoclinical study of a case

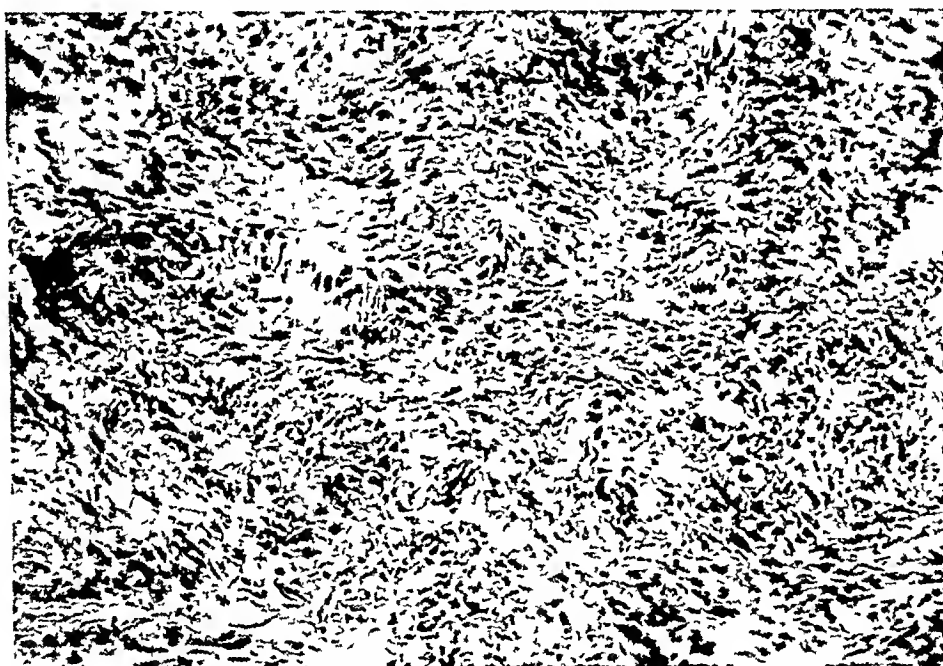


FIG. 3.—Photomicrograph (low power) showing oval shape of cells with frequent palisade arrangement of the nuclei.

of pedicled "exogastric" tumor. The histologic examination showed the growth to be of nervous origin, "analogous to the visceral tumors seen in von Recklinghausen's disease."

In 1932, appeared Masson's¹⁴ monograph, *Experimental and Spontaneous Schwannomas (Peripheral Gliomas)*, "addressed to that minority of pathologists who still refuse to admit that the fundamental constituent of the encapsulated tumors of the peripheral nerves is the schwannian syncytium, a neur ectodermal structure and not the mesodermal fibroblast." This did much to clarify the entire subject of tumors arising in the nerve sheaths, and to permit recognition of the benign nature of the majority of those growths when they appeared infrequently in the digestive tract. But Masson's opinion was not universally accepted. Four years later we find two French pathologists, Leveuf and Godard,¹⁵ writing of "cavitary sarcomata of the small intestine in chil-

dren," and discussing, in particular, the pedicled variety, remarking "These pedicled tumors are not true sarcomas, in the majority of cases they should not only be exempted from that classification, but should rather be definitely classed as neurofibromata "

Visceral neurofibromata may occur as a solitary growth or they may appear as multiple tumors Ewing²⁷ states that they may be found anywhere in the intestinal tract "from the lips to the anus " The importance of establishing the true nature of these growths needs no emphasis Although they may undergo malignant degeneration, they are no doubt primarily benign, and should be treated as such

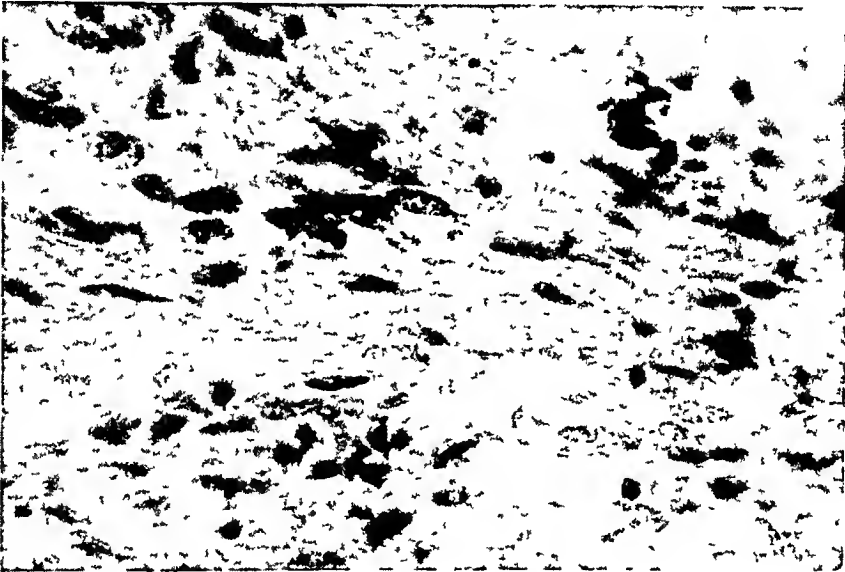


FIG 4—Photomicrograph (high power) of Figure 3 showing details of cell arrangement

From a review of the more recent literature, it is evident that there is still a difference of opinion as to the classification and histogenesis of these tumors They have been described under many different names "Neurinoma" and "schwannoma" appear most frequently in foreign reports They have also been designated as peripheral gloma, fibroblastoma, neurilemoma, perineural fibroblastoma and neurogenic fibrome, depending upon the opinion of the writer as to the structure or origin of the growth described According to Ewing "a satisfactory classification of these tumors is difficult, owing to the complex structure of the nerve trunks, the uncertainty of the source of the supporting cells which accompany nerve fibers such as the cells of the sheath of Schwann, the neurilemma, the endoneurium and the lymph sheaths of nerve trunks, all of which participate in tumor growth "

On account of the confusion in terminology it has been extremely difficult to make an accurate estimate of the number of cases that have been reported This has been particularly true in the preceding decade However, I have been able to collect 18 cases that have been operated upon since 1929 From a study

NEUROFIBROMA OF INTESTINE

TABLE I

ANALYSIS OF 18 CASES OF NEUROFIBROMA OF THE SMALL INTESTINE REPORTED SINCE 1929

Authors	Sex	Age	Principal Signs and Symptoms	Path Report	Operation and results
Dudley (1930) ⁹	F	49	Abdominal pain	Benign	Resection—Recovery
Picard (1932) ¹²	F	54	Intestinal obstruction	Benign	Resection—Recovery
König (1932) ¹⁰	F	40	Hemorrhage, acute peritonitis Tumor felt per vagina	Benign	Resection—Recovery
Denecke (1932) ¹³	F	53	Abdominal pain and palpable tumor	Malignant	Exploratory Celotomy Death within 10 days
Lemonnier & Peycelon (1933) ¹⁵	M	42	Intestinal hemorrhage	Benign	Resection Death from shock
Nordlander (1933) ¹¹	M	73	Intestinal hemorrhage	Malignant	Resection Death several hours later
Baumeister (1934) ¹⁷	F	59	Symptoms of acute appendicitis	Benign	Resection—Recovery
Borras & Benito (1936) ¹⁸	F	54	Abdominal pain and palpable tumor	Benign	Resection—Recovery
Arnvig (1937) ²⁰	M	47	Intestinal hemorrhage—palpable tumor	Benign	Resection—Recovery
Bergendal & Sjövall (1937) ²¹	M	29	Acute peritonitis	Malignant	Resection — Death from recurrence 4 yrs later
Graffin (1939) ²³	F	51	Intestinal obstruction	Benign	Resection—Recovery
Babbini & Tettamanti (1939) ²⁵	M	59	Abdominal pain and palpable tumor	Benign	Resection—Recovery
Mouchet & Samain (1939) ²²	F	73	Abdominal pain	Benign	Resection—Recovery
Miller & Frank (1939) ²⁴	F	72	Abdominal swelling and distress	Malignant	Excision — Recovery 6 mos after operation without complaint
Miller & Frank (1939) ²⁴	M	47	Loss of weight and abdominal discomfort	Malignant	Resection Death 3 mos later
Bonniot (1939) ²⁶	M	64	Abdominal pain and palpable tumor	Malignant	Resection Death from recurrence
Colillas & Masciottra (1940) ²⁸	F	46	Palpable tumor	Benign	Resection—Recovery
Schousboe (1941) ²⁹	F	51	Symptoms of acute appendicitis	Benign	Resection—Recovery

of the pathologic report of these cases, 12 were found to be benign and six were malignant. All of these cases, with the exception of one, were of the solitary type.

There is no uniformity in the clinical details furnished by those who have reported these cases of intestinal neurofibromata. The growths had in all probability existed for a long time without producing any symptoms whatsoever. The youngest patient was 29, the oldest 73, the average age being 53.5. There were seven males and 11 females. Some of the patients gave a history of gastro-intestinal disturbances which may well have been due to the presence of the tumor, but none of these manifestations could be considered pathognomonic. In some of the cases cited there was a personal or familial history of von Recklinghausen's disease, but this did not occur often enough to establish any positive pathologic background upon which a characteristic clinical picture could be projected. Abdominal pain and palpable tumor were the most frequent complaint, the former being present in eight patients and the latter in seven. Appendicitis would appear to have been the preoperative diagnosis in two of the cases. In four cases exploration was performed on account of intestinal hemorrhages. Intestinal obstruction occurred in three cases, including

my own In several instances peritonitis was evident when the patient came under examination, but its cause was determined only after the abdomen had been opened Perforation of the bowel took place in several cases where the tumor had become necrotic, or had attained so great a size as to cause pressure atrophy or necrosis in some adjacent structure

Case Report—P L, colored, male, age 65, was admitted to the hospital, January 8, 1939, complaining of pain in the lower abdomen of 48 hours duration The pain was colicky in character and had grown progressively more severe Purgatives had been given, but the patient stated he had been unable to retain them There had been fair results from several enemata, but no relief from the pain Twenty-four hours before admission he had begun to vomit, and had been able to retain nothing thereafter The patient's health had been fairly good except for an occasional gastro-intestinal upset He had, however, noticed a mass in his lower abdomen which had been present for about a year As it was not painful he had ignored its presence

Physical Examination—The patient was a somewhat emaciated colored man, weighing about 135 lbs, and who appeared older than his stated age His knees were drawn up against his greatly distended and tympanitic abdomen, and he appeared to be in intense pain Despite distention, the mass could easily be palpated in the middle line Roentgenologic examination, after the administration of a barium enema, revealed no abnormality in the colon or sigmoid Except for many defective teeth, his head, chest and extremities were negative Blood pressure 120/80, temperature 98.6° F, pulse 90, respirations 30, R B C 4,320,000, W B C 12,150, hemoglobin 88 per cent, polymorphonuclears 83 per cent, lymphocytes 17 per cent Urinalysis was negative save for a trace of albumin Kahn and Wassermann tests were negative *Preoperative Diagnosis* Acute intestinal obstruction, complicating an intra-abdominal tumor of unknown character

Operation—A lower midline incision exposed a solid tumor, ovoid in shape, the size of a small grapefruit, attached to the periphery of the small intestine in the region of the lower ileum by a pedicle 2 cm in length The growth arose from the bowel wall and was entirely outside the intestine, not encroaching upon the lumen in any way It was not adherent to any structure, but was lying entirely free in the abdominal cavity By twisting on its pedicle, which was about 1 cm in diameter, the tumor had so rotated the section of intestine to which it was attached as to bring about a volvulus (Fig 1) Though the entire loop of intestine was enormously distended, no circulatory damage had occurred The pedicle was clamped, cut and ligated, and the tumor was removed This released the volvulus and permitted the fecal current to resume its flow The abdomen was closed without drainage, and recovery was prompt

Pathologic Examination—Gross Dr Arnold F Strauss The tumor measures 12 x 7.5 x 6 cm, weighs 342 Gm, has a well preserved capsule, showing on one side a smaller node about the size of a walnut Consistency of tissue is about that of liver, the cut surface being unstructured, of a pink and grayish-white color, one pole being of a darker pink, with a dark red margin (Fig 2)

Microscopic The section shows fascicles of fibers with rod-shaped or slightly oval nuclei, which tend to palisade structure (Figs 3 and 4) Upon cross-section the protoplasm of the fibers is often slightly fibrillary or foamy Extensive areas are edematous, with regions of hemorrhages, round cell infiltration and occasional leukocytes Many capillaries are present, some vessels being much dilated and showing thrombosis von Gieson's staining reveals a very few fine collagen fibers which often surround the fascicles **Pathologic Diagnosis** Neurofibroma of the small intestine This diagnosis is based on the palisade structure of the nuclei, together with their oval shape, and upon the scarcity of collagen fibers, as demonstrated by Masson, Gosset, and others

The difficulties of comparing my own case with those previously reported will be evident to anyone who has familiarized himself with the literature which my necessarily incomplete review has shown to be highly controversial and inconclusive. There is agreement, however, upon certain main points, as, for example, the structure of the nerve trunk from which the growths under discussion take their origin. This trunk is made of *axones*—that is nerve cell processes—which are enclosed in a sheath, the *neurilemma* or sheath of Schwann. The axones sometimes (but not always) have a myelin coating as well, but are regularly surrounded by a network of extremely delicate connective tissue—the *endoneurium*. The small bundles of nerve fibers which the endoneurium supports assume an arrangement of strands or funiculi about which is another connective tissue covering—the *perineurium*. Surrounding and supporting all the structures of the nerve trunk is a connective tissue envelope or sheath—the *epineurium*. Thus, it appears possible for new growths to arise from either of two structures—the neurilemma itself or the connective tissue which surrounds it. Embryologists are in agreement as to the process by which these nerve elements develop during fetal life. The neurilemma or sheath of Schwann, as well as the nerve cell process, are of epithelial origin, while the connective tissue, the epineurium, perineurium and endoneurium are derived from the mesoderm. But from this point we find no agreement as to just how or why the growths we are now considering make themselves manifest in the nerve tissues. Masson, as we have already seen, believes that the cells of the neurilemma are the parent tissues. While this explanation is perhaps the most logical offered for any single point of origin, to take a more conservative position and admit the possibility of their growing not only from the sheath of Schwann, but also from the connective tissue, makes for a simpler and more workable hypothesis.

From the most generally recognized pathologic description, neurofibromata as they appear in the small intestine are regularly benign, though they occasionally manifest a low degree of malignancy. The mass is encapsulated and frequently pedunculated, and most of the specimens are ovoid or spherical. If much connective tissue stroma is present the growth will be hard, and, in general, it may be stated that the firmer and harder the mass the more benign is its character. Those which resemble brain tissue in color and consistency are liable to be malignant, and though nearly all growths show some cavities, the benign ones are more firm and solid than those giving evidence of malignancy upon microscopic examination.

Under the microscope the cells appear in whorls or more commonly in bundles which interlace, with a very frequent palisade arrangement which Masson, and those of his school of opinion regard as the distinctive appearance peculiar to growths coming under the classification "neurofibroma." The cells are stellate and elongated, while in certain spots they will be plainly polygonal. Because the walls of the abundant blood vessels are extremely thin, rupture is almost regularly evidenced by extensive hemorrhagic areas, some of the cavities which are lined with endothelium appearing to be filled to overflowing.

with blood, which may also have infiltrated into the surrounding connective tissue stroma. Miller and Frank²⁴ make the interesting observation that as motor paralysis seldom occurs as an accompaniment to these particular nerve tumors it would indicate that they arise only on sensory nerves, so "if this reasoning is correct it may explain the infrequency of neurofibromata in the gastro-intestinal tract, since its sensory nerve supply is meager." Because of its great rarity and protean clinical manifestations this particular neoplasm will no doubt continue to vex diagnosticians whenever it occurs. The question of classification has more than academic significance, as it bears largely upon the form of treatment to be adopted. Benign growths may be removed by simple resection, or, as in my own case merely by severing the tumor's attachment to the bowel. Even those of large size which have induced pressure necrosis can be handled without wide resection or elaborate precautions against recurrences which even a suspicion of malignancy entails.

SUMMARY

- 1 All benign tumors of the small intestine are rare
- 2 Neurofibromata of the small intestine were first reported at the end of the nineteenth century but the existence of neurofibromata in subjects not affected with generalized neurofibromatosis was not recognized until recently
- 3 Exact pathologic classification of these new growths has yet to be established
- 4 The pathologic diagnosis is based upon the palisade structure of the cell nuclei, the oval shape of the cells, and the scarcity of collagen fibers
- 5 Eighteen cases which have been reported since 1929 have been analyzed
- 6 One additional case is reported and described
- 7 The importance of differentiation between benign and malignant growths of similar structure is emphasized, because of the ease with which benign growths may be surgically treated in contrast to the difficulties and dangers inherent in handling any type of malignant neoplasia

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MASSIVE RESECTION OF THE SMALL INTESTINE*

REPORT OF TWO CASES

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THE PURPOSE of this paper is to discuss briefly massive resection of the small intestine and to report two cases, one of which survived the resection of 260 cm of small intestine, with 31 cm of sigmoid colon, and two subsequent major operations for reestablishing the continuity of the large intestine, who, finally, regained an excellent state of health, and the other case who survived the resection of 354 cm of small intestine, with 40 cm of sigmoid colon, but pursued a generally downhill course, and died four months later of nutritional disturbances and postoperative complications

Massive resection of the small intestine is of interest both from the immediate survival of a critically ill patient from an extensive emergency operation with not infrequently, secondary operations for establishing intestinal continuity, and later from the standpoint of nutritional disturbances following the loss of a large section of the bowel. The term is applied to those cases in which 200 cm, or more, of small intestine have been resected. This is generally estimated at one third the total length, though there must be considerable variation with individuals, and in children it is relatively a greater proportion of the whole. The most complete review is that of Haymond,¹ in 1935, in which he analyzed a series of 257 carefully selected cases. In this series the mortality was 33 per cent, but this is considered as unduly low due to the greater tendency to report the successful cases. In some cases a portion of sigmoid colon is involved and requires resection. This adds greatly to the operative risk but has no significant bearing upon the nutritional status. In this group the mortality is highest, being 65 per cent. The two cases herewith reported are of this type. Volvulus is the most common condition necessitating such an extensive resection. Among others are strangulated hernia, mesenteric thrombosis, adhesions and abdominal injuries.

Besides the length of the intestine resected, the immediate outcome is determined by the disease condition which necessitates the resection and the general health of the patient. While there appear to be some exceptions, the nutritional status is definitely affected by the relative amount of bowel removed. Discounting the operative risk and postoperative complications a patient may be expected to regain a normal nutritional status following the removal of 33 per cent of the small intestine. Fifty per cent is given as the

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upper limit which may be borne, with a possibly satisfactory outcome. A loss greater than this is almost invariably followed by serious nutritional disturbances of varying degree.

Inadequate compensatory changes following massive resection of the small intestine result in loss of weight, anemia and diarrhea, and at times, edema. There is excessive loss of fat and protein in the stools. The blood calcium and serum proteins are low. In a remarkable case reported by West, *et al*,^{2,3} in which only three feet of jejunum remained, there was noted at a subsequent operation considerable dilatation and hypertrophy of the remaining bowel. Extensive metabolic studies led to the conclusions that carbohydrate is well assimilated, protein less well, and fat only poorly. The large amount of fatty acid in the stool apparently carries with it calcium in the form of calcium soap, leading to a negative balance of this mineral. Their patient did best on a high carbohydrate, adequate protein, low fat diet with additional calcium and vitamin D. Observations of others are along the same lines^{1,4}

CASE REPORTS

Case 1—Hosp No R 110430-4511. W. A., Negro, male, age 31, was admitted to the Roper Hospital May 7, 1940, at 10:30 A. M., complaining of severe pain in the abdomen, which had begun in the epigastrium at 5 A. M. There was vomiting at the onset but none subsequently. The pain was rhythmic in character and varied in severity, but was always present in some degree. His general health had been good and there was no history of indigestion or of any previous attack. He was well-developed, well-nourished, and had an ashen grey complexion. He was obviously acutely and critically ill. He was writhing with pain. Temperature 96° F, pulse 70, and B. P. 120/80. His abdomen was moderately distended and tympanic. There was a general tenderness and rigidity. There was no visible or audible peristalsis. Rectal examination revealed some fullness in the rectovesical pouch. W. B. C. 15,500, with 91 per cent polymorphonuclear cells. A specimen of urine could not be obtained. Roentgenologic examination revealed some fluid levels in the small intestine and gaseous distention of the large bowel up to the splenic flexure. *Clinical Diagnosis*—Intestinal obstruction, with strangulation.

Operation—5 P. M. Spinal anesthesia with pontocaine 20 mg. was given. A few minutes after the subarachnoid injection the patient had generalized severe convulsions, respiration ceased, and the pulse became imperceptible. He reacted somewhat to artificial respiration, inhalation of oxygen and carbon dioxide, and injections of coramine and ephedrine, though he remained in shock throughout the operation. A right paramedian incision was made. All of the small intestine in view was of a dark, blue color, likewise its mesentery. The gangrenous portion was resected with its mesentery. A section of the gangrenous large bowel was twisted with the small intestine in such a manner that it had to be divided before it could be sufficiently mobilized to permit of resection. An end-to-end open anastomosis was made between the proximal end of the small intestine and the distal end, which was 6 cm. from the cecum. A Witzel enterostomy was made proximal to the anastomosis, bringing the tube out through a stab wound on the right. The appendix was removed. The distal end of the large bowel would not reach the abdominal wall so it was closed by inversion and dropped into the pelvis. The proximal end of the large bowel was brought out through a stab wound to the left of the umbilicus to act as a colostomy. The incision was closed with catgut for the peritoneum and fine alloy steel wire for the aponeurosis. The operation took one hour and forty-seven minutes.

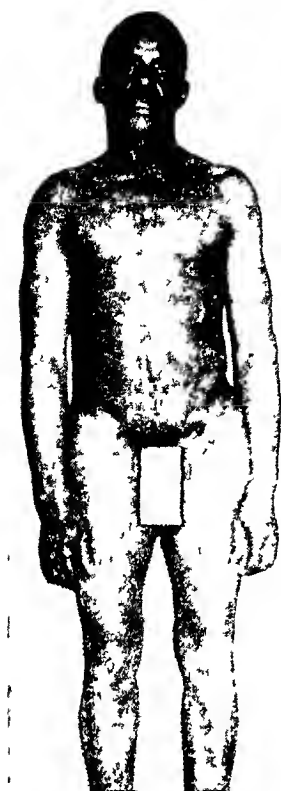


FIG 1—Case 1. Appearance of patient 18 months after operation

The patient was returned to the ward in fair condition. The specimen removed, as measured 15 hours later, consisted of 260 cm of gangrenous small intestine, with its mesentery, and two segments of gangrenous colon, measuring 19 and 12.5 cm, respectively. The appendix had a thick serosa and a scarred wall.

Postoperatively the patient was given continuous stomach suction and lavage through a Wangensteen tube. Sodium sulfapyridine was administered intravenously. The abdomen remained flat and the convalescence was remarkably smooth. On May 10 the enterostomy began discharging freely, and on May 13 the colostomy did likewise. The enterostomy spontaneously closed following removal of the tube on May 17. On May 20 there was noted some purulent discharge and slough at the upper end of the incision. On June 19 roentgenologic examination with a barium enema revealed the distal end of the colon to be 20 cm from the anal orifice.

On June 25, under spinal anesthesia, in preparation for anastomosing the ends of the sigmoid colon, numerous dense adhesions were severed from around the proximal end, and a double barrel transverse colostomy was made. On July 16, under spinal anesthesia, through a low left rectus incision dense adhesions were freed, and with difficulty the ends of the colon were mobilized for anastomosis. This was accomplished by attaching a stout ligature to the proximal end and telescoping it into the distal segment by a forceps passed through the anal orifice. No other method of anastomosis was possible due to the fixation and induration of the distal end, which had to be split to permit passage of the proximal end. Following this operation there were several brief periods of diarrhea, which were readily controlled by dietary regimen.

Until August 15, a period of one month, when dye instilled into the distal loop appeared at the anal orifice, there was complete obstruction at the site of anastomosis. Later a Levine tube was passed from above, and subsequently dilatation was effected by passing bougies from below. From October 1 to November 17, the colostomy spur was crushed in stages. On November 22, the colostomy was closed under local anesthesia. On November 24, four months after the anastomosis, there was a bowel movement by the rectum. On November 30 the patient was discharged from the hospital. His general condition was good. He was eating the ward diet. He was passing several poorly-formed stools a day. The abdominal incisions were firmly healed. Laboratory examinations were as follows: WBC 8,075, Hb 10.5 Gm. Urine: Albumin one plus, blood serum protein 8.20 Gm—albumin 4.7 Gm—globulin 3.43 Gm—chlorides 495 mg—blood Wassermann—positive—Stools: Yellow and putty-like, muscle poorly digested.

On December 29, 1941, he returned to the hospital for observation at our request. He had been enjoying good health and working at his former occupation as a laborer in a fertilizer factory. He paid no particular attention to diet. He preferred carbohydrates and proteins, but ate fat without ill effect. He had no digestive disturbance or abdominal pain. His weight was 138 lbs, a very good average for him. He had one bowel movement a day. Roentgenologic examination revealed no abnormality other than a shortening of the small intestine and a correspondingly short emptying time. Examination of the urine was negative. WBC was 7,700, hemoglobin 12 Gm.

MASSIVE RESECTION OF INTESTINE

Blood sugar 81 mg—calcium 12 mg—phosphorous 8.25 mg—total serum proteins 8.25 Gm, albumin 4.3 Gm, and globulin 3.9 Gm. The stools were yellow and mushy.

He was last examined on October 10, 1943. He was working as a laborer for a railroad. His general health was good. He was having two or three bowel movements a day. He paid no attention to dietary restrictions. The stools were well-formed and normal microscopically. Blood calcium 10 mg,—phosphorus 3.5 mg,—total serum protein 7.61 Gm,—albumin 4.88 Gm,—globulin 2.73 Gm, and hemoglobin 12 Gm per 100 cc.

Case 2—(Reported by courtesy of Dr. Frederick E. Kredel) (Hosp. No. R 8382) J. S., Negro, male, age 56, was admitted to the Roper Hospital at 11 A.M. May 16, 1942, complaining of abdominal pain. He had been awakened at 1 A.M. by a sudden, sharp pain in the region of the umbilicus. The pain became steady but varied in intensity in rhythm, each cycle lasting 15 minutes. He had vomited continually since the onset. He had no passage by rectum. He had been losing weight the past few months and had noticed an increasing tendency to constipation. He appeared acutely ill and had an anxious expression. Pulse 70, temperature 97.4° F,—B.P. 60/40. The abdomen was considerably distended and tympanitic, no bowel pattern was visible. Rectal examination was negative. In view of a questionable pericardial friction rub, an electrocardiogram was made. It showed changes best explained by anoxemia incident to peripheral circulatory collapse. W.B.C. 15,400, with 88 per cent polymorphonuclear cells. *Clinical Diagnosis* Intestinal obstruction from mesenteric thrombosis. For the purpose of investigating the cardiac condition and of treating the shock, operation was deferred until 10 P.M.

Operation—Under nitrous oxide-oxygen-ether vapor anesthesia, a left lower paramedian incision was made. Two quarts of foul-smelling bloody fluid was aspirated. All but the proximal seven feet of small intestine and the terminal ileum was gangrenous, also two feet of sigmoid. The condition was apparently due to a volvulus. The gangrenous bowel was resected. A side-to-side anastomosis of the small intestine was made. The distal end was closed and a tube was inserted through the proximal end to act as an enterostomy. The ends of the large bowel were sutured side-by-side and brought out as a double barrel colostomy. Eight grams of sulfanilamide powder were sprinkled in the abdominal cavity. The wound was closed with chromic catgut and through-and-through silkworm gut sutures. The operation lasted one hour and eighteen minutes. At the end, the condition of the patient was very poor.

The specimen removed at operation consisted of 354 cm. of gangrenous small intestine, and 40 cm. of large intestine, with vascular engorgement, hemorrhage and edema.

For several days the general condition of the patient was very poor. He was disoriented, excited and resistive. His abdomen remained scaphoid. The ileostomy tube drained freely. On May 24 a crushing clamp was applied to the colostomy spur. On May 25 the enterostomy tube was removed. On June 4 it was noted that there was profuse discharge through the fistula at the ileostomy site. The general course was downhill. For the next six weeks the intestinal drainage was profuse and caused excoriation of the surrounding skin. The patient was oriented but persisted in being resistive and uncooperative. On August 6 the fistula was much smaller and the patient was discharged to the Out-patient Department. He was eating well but his state of nutrition was poor. He had four or five soft, yellow, foamy bowel movements a day. Total serum protein was 6.99 Gm,—serum albumin 4.91 Gm,—serum globulin 2.08 Gm,—chlorides 539 mg,—urea nitrogen 16 mg,—blood Wassermann positive. W.B.C. 7,600, polymorphonuclear cells 66 per cent. Hb 8.5 Gm. Urine. Albumin three plus, W.B.C. 15, R.B.C. 3 per hpf.

On September 4, 1942, he was again admitted to the hospital with a diagnosis of intestinal obstruction. He had noticed increasing abdominal distention during the past week, though his bowels continued to move and the intestinal fistula continued to drain.

He was irritable, emaciated and anemic, but in no acute distress. The abdomen was drum-tight. He did not improve under treatment by continuous stomach suction. The blood chemistry findings were the same as on discharge August 6. On September 11, under spinal anesthesia, operation was performed for the purpose of relieving the obstruction and closing the fistula. A right rectus incision was made in line with the fistula. About five liters of ascitic fluid was found. The intestines were edematous but not discolored or much distended. The terminal ileum was kinked by dense adhesions. The fistulous tract was complicated involving the colostomy and terminal ileum. After considerable dissection the openings in the intestines were closed. On September 12 distention reappeared. The patient developed peritonitis, and died September 15, 1942.

COMMENT—Case 1 is of interest from the standpoint of the patient's regaining good health following the resection of approximately 40 per cent of the small intestine, with a section of sigmoid colon, and two subsequent major operations for reestablishing intestinal continuity. No hernia resulted, though three longitudinal incisions were made in a contaminated field. This is partly attributed to the use of alloy steel wire. The telescoping anastomosis of the rectosigmoid resulted in stricture formation, which was dilated only with difficulty but showed no tendency to recur. Examination three years later indicated that he had regained a state of normal health.

In Case 2 the patient survived removal of approximately 53 per cent of the small intestinal and a section of large bowel. Though he lived for four months his course was generally downhill. His nutritional disturbance was increased by a small intestinal fistula which drained more or less profusely for six weeks after operation, but it did not improve following diminution of the drainage. Edema appeared early. That the blood serum proteins were not lower is probably accounted for by the state of dehydration. The nutritional changes were those to be expected. The development of partial intestinal obstruction necessitated operation four months later. Of particular interest was the finding of a large amount of ascitic fluid and edema of the intestines.

SUMMARY

- 1 The subject of massive resection of the small intestine has been reviewed.
- 2 Two cases are reported, one regained a normal state of health, the other died of nutritional disturbances and postoperative complications after four months.

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SIMPLE PENETRATING ULCER OF THE CECUM⁺

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SIMPLE ULCER OF THE CECUM, a lesion not associated with other recognized infections nor tumefactions of the large bowel, is usually found near the ileocecal valve on the mesial side of the cecum and has a marked tendency to perforate and to cause extensive scarring and contraction. While so-called "simple" ulcers of the colon were first described by Cruveilhier a century ago, the condition is still rarely reported. It still presents a clinical picture so confusing that no case has ever been clearly differentiated from other lesions of the ileocecal coil before celiotomy or autopsy, and is still completely obscure as to its etiology.

The first collected report of nonspecific colonic ulcers was made in 1902 by Quenu and Duval, who reviewed 27 cases, including in their series lesions from all portions of the large bowel. Barron's collection of 53 cases, presented in 1928, also attempted the correlation of ulcers from this comprehensive field. In each of these reports, cecal lesions far outnumbered those in other portions of the bowel, moreover, the cecal cases, when analyzed by the reader, suggest a definite clinical entity more clearly than the ulcers found in the left colon, since we now understand that ulcerative colitis, amebiasis, diverticulitis and other disease processes partial to the left colon could have been responsible for the lesions found there.

It is perhaps for this reason that recent surgical literature reveals a distinct tendency to segregate the single, nonspecific, penetrating ulcer of the right colon as more nearly answering the essential criteria for a pathologic entity.

Males of middle age are more prone to this condition, although it has been encountered in both sexes and in individuals from 17 to 80 years old. The symptoms of the disease are so variable and pathognomonic signs so lacking that continued difficulty in specific diagnosis is understandable, but it is fortunate that the clinical manifestations which are present clearly demand surgical intervention, as no medically treated individual has survived.

In the acute form, where perforation has occurred or is imminent, the symptoms are apparently indistinguishable from those of appendicitis, in fact, Barlow states that in 68 per cent of those cases in which diagnosis has been attempted, the abdomen has been explored under that misconception. Dickenson, who encountered at long intervals three individuals with cecal ulcer, stated that he operated upon each in turn with the preoperative diagnosis of appendicitis. Excision and suture of the ulcer, or suture alone has been used successfully by Cameron, Barlow, Harrison and others when

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the ulcer evidenced recent perforation without tumefaction of the bowel, but when drainage alone was relied upon the outcome has invariably been fatal.

When the perforative process is slow, the associated fibroplastic reaction gradually produces extensive tumefaction of the cecum, ascending colon and even the nearby ileum, and when the omentum attaches itself to the ulcer bed a similarity to neoplasm becomes even more marked. In this chronic latent stage constipation is a common symptom, vague abdominal pain, low-grade fever, slight tenderness over the mass in the right lower quadrant and, more rarely, intestinal bleeding may be encountered. Since the ileocecal coil is the location of the great majority of those inflammatory conditions of the abdomen which require surgical treatment, as well as the site of one-fourth of colonic cancers, it is evident that a variety of pathologic lesions can present signs and symptoms similar to those of chronic simple ulcer of the cecum.

Periappendicitis may of course give rise to the firm, woody pseudotumor described by Walters and Synhorst as "ligneous" infection of the cecum. Hypertrophic tuberculosis of the cecum, frequently a primary lesion and causing mild local tenderness, discomfort, indigestion and occasional bleeding from the bowel, not only produce a similar mass but presents the same roentgenologic picture of constriction, as the process is associated with excessive fibrosis and consequent thickening of the bowel wall. The chronic granulomatous disease, regional ileitis, begins by preference at the ileocecal valve and extends upward along the terminal ileum, but direct extension to the cecum may occur. In the chronic form a palpable mass is present, consisting of soggy, edematous, adherent bowel and omentum. Diarrhea, fever, extreme chronicity and a tendency to occur in younger individuals should, of course, differentiate this lesion from ulcer. Cecal cancer is frequently palpable although, in theory, the absence of pain and fever and the presence of anemia should aid in its differentiation. The roentgenologic examination is not always helpful, however, as a malignant cecal tumor not infrequently produces a constricting defect.

A review of the chronic or latent cases reported discloses that cancer has been the most common preoperative or postoperative diagnosis and that resection of the right colon has usually been considered advisable.

My own observation of this disease includes two cases, both seen in the latent phase.

CASE REPORTS

Case 1—C. H. H., white, male, age 68, was transferred to the Proctologic Service of the City-County Hospital, February 2, 1941, with the chief complaint of indefinite pain in the right lower quadrant for 18 months. The discomfort had been much more severe for three months, and periodic attacks associated with abdominal cramps during that time had been relieved by vomiting. No blood had been seen in the stool, and there had been little temperature elevation, but the patient had observed an increase in constipation.

Examination disclosed a firm, movable, palpable tumor in the right lower quadrant,

ULCER OF CECUM

with no rigidity, no fever, slight leukocytosis, and no anemia. A colon roentgenogram was done (Fig 1), and the following observations made: "Marked deformity of the cecum, chiefly narrowing near the ileocecal valve, movable tumor in this area, spasm apparently associated with the tumor. *Impression*: Organic constrictive lesion of the cecum. Neoplasm considered first, hyperplastic tuberculosis second, and specific inflammatory process third."



FIG 1—Case 1 Radiograph showing spasm and constriction of ascending colon and cecum

On February 12, 1941, the abdomen was explored, with the preoperative diagnosis "cancer of the cecum." A sausage-shaped tumor was found, no change in the liver nor abdominal nodes was noted. An ileocolostomy was done. A rise in temperature occurred after this procedure, but subsided. On February 26, with the diagnosis "tumor" of the cecum, the right colon was resected. Grossly, a dimpled area was noted near the ileocecal valve, together with marked constriction of the cecum and a portion of the ascending colon. The tissue report was as follows: "The cecal mass measured 11 x 7 x 6 cm. In one area a definite constriction was seen, the mucosa was ulcerated and the bowel wall thickened. A portion of the wall on the medial side was deeply necrotic. Microscopic findings: Ulceration of the mucosa which was infiltrated with lymphoid and plasma cells. In the center the ulceration was deeper, at the periphery, marked fibrosis was observed. No neoplastic nor specific changes were seen. *Impression*: Chronic, nonmalignant, nonspecific solitary ulcer of the cecum."

The patient died ten days following his second operation from peritonitis induced by leakage of the intestinal suture line. An autopsy disclosed that, other than the peritonitis, no lesion of the intestinal tract nor abdomen was present.

The condition was encountered by us again in December, 1942, the patient, again, being an elderly individual with a subacute hyperplastic lesion, which had apparently partially perforated three weeks before entry into the hospital

Case 2—S W, white, female, age 65, married, was first examined on December, 1942. She stated that she had noted for some months mild indigestion with flatulence, but that for three weeks a cramping pain had been present in the abdomen, especially in the right lower quadrant, associated with slight nausea. The bowel habit was



FIG 2—Case 2 Radiograph showing constriction of cecum. Efforts to fill this portion of the bowel with barium were unsuccessful.

unchanged, there was an increase in the leukocyte count but the red cell count was normal. A mass was palpated in the right side. A roentgenogram demonstrated a filling defect in the cecum, associated with constriction (Fig 2).

At exploration, under the preoperative diagnosis "cancer of the cecum," this portion of the bowel was found enlarged, firm and surrounded by omental adhesions. An ileocolostomy was done, which was followed by a stormy convalescence and irregular temperature.

Several weeks later, under the rather evasive preoperative diagnosis "tumor of the cecum," the abdomen was entered again. Some free fluid was found but conditions were otherwise unchanged. The right colon was resected at this time. The pathologic report was as follows: "In the cecum, 2.5 cm from the base of the appendix, there is a firm ulcerated area. The wall of the cecum is thickened and the overlying peritoneum

of the terminal ileum is thick and roughened. Microscopically, it is shown that the ulcer extends through all the layers of the bowel, its base consisting of granular tissue infiltrated with leukocytes, in the fibrotic tissue surrounding the ulcer an irregular scattered round cell infiltration is noted. Sections of the ileum reveal normal mucosa with infiltration of the serosa and submucosa with round cells, a nearby lymph node revealed hyperplasia of the reticulo-endothelial elements. No evidence of any specific etiologic change was observed in the tissue examined. *Diagnosis* "Simple ulcer of the cecum with partial perforation and subacute pericecitis and periappendicitis"

While less than 50 cases of simple ulcer have found their way to the literature, it is probable that numerous unreported or unrecognized examples of this pathologic entity have occurred. Osler, for example, briefly and without detail, mentioned that "two instances of ulcer of the cecum, both with perforation, have come under my observation," and Whipple recently listed cecal ulcer as the cause of two resections of the right colon. While it is true that no proven etiologic agent can be assigned to this condition, this is no less true in the case of a similar phenomenon, peptic ulcer.

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DISCUSSION—DR J. SHELTON HORSLEY, Richmond, Va. Doctor Collins has gone very interestingly into the subject of neurofibromas. As he said, there has been much discussion of neurofibromas of the intestinal tract, and doubtless many tumors that have heretofore been classified as myomas or fibromas or leiomyosarcomas may be found on reexamination to be neurofibromas. The palisade effect in the microscopic examination to which Doctor Collins called attention is a rather important point in diagnosis and tends to confirm the diagnosis of a neurogenic tumor.

Occasionally there are degenerating neurofibromas. A case of mine was rather puzzling. Mrs. K. W., age 39, had suffered from intestinal hemorrhages at repeated intervals for several years. Her hemoglobin was 32 per cent, R. B. C. 2,880,000. Gastro-intestinal roentgenologic examination was negative. The physical examination was essentially negative. A tentative diagnosis of duodenal ulcer was made and, on operation, there was found at the hepatic flexure of the transverse colon, a flat mass arising from the transverse mesocolon and attached to the jejunum. It was extremely vascular. Part of the jejunum and a large segment of the transverse colon were resected. The patient made a satisfactory recovery. The tumor was a vascular, degenerating neurofibroma springing from the transverse mesocolon and invading the upper jejunum at the point which was the source of the hemorrhage (slide). The next slide

shows the microscopic appearance ($\times 150$) According to Broders, this is a degenerating neurofibroma, and is essentially benign

Another slide is from a tumor of the stomach that I formerly classified as low grade leiomyosarcoma The palisading effect is well shown, however It seems probably that this tumor is a type of neurofibroma After resection of the stomach there has been no recurrence

DR WALLACE FRANK, Louisville, Ky In 1939, Miller and I reported two cases of nerve tumors of intestinal origin before the American Association for the Study of Neoplastic Diseases We submitted sections which greatly resembled in most detail the photomicrographs shown by Doctor Collins It was their opinion that the cases which we reported were not simple neurofibromas but rather neurofibrosarcomas One case we reported was truly von Recklinghausen's disease of the small intestine There were thousands of lesions ranging in size from a pinpoint to a baseball This man died of intestinal obstruction At autopsy no evidence of any metastasis was found

I would like, with Doctor Rosser's permission, to add to the literature another case of simple ulcer of the cecum The best article I have seen on this subject was by Cameron, published in the British Journal of Surgery, January, 1939 Cameron emphasizes the fact that the ulcer is always opposite the ileocecal valve He compares simple cecal ulcer to duodenal ulcer and states that the acidity of the material being poured through the valve may be a causative factor

Case Report—C T, a man, age 23, was first seen in May, 1937 He gave a history of pain in the abdomen, nausea but no vomiting The symptoms began 40 hours prior to the time I saw him His temperature was slightly elevated, pulse about 96 There was definite tenderness and rigidity of the lower right rectus muscle The white blood count was approximately 16,000, with 79 per cent polys He was seen in the afternoon and operated upon as an emergency At operation, the appendix was definitely reddened and congested, and was removed It did not seem to be acute enough to account for all his symptoms, consequently I carefully explored the terminal ileum but found no pathology Palpation of the cecum revealed a hard indurated area on its postero-external wall The peritoneum to the outer side of the cecum was incised and the cecum turned inward This exposed a grayish-white area about 1.5 inches in diameter and 0.5 inch thick, in the center a definite crater could be palpated As the lesion was extraperitoneal I deemed it unwise to excise it There was not enough peritoneum over the cecum to do a resection of the cecum, and as the patient had not been prepared for any radical surgery I thought it inadvisable to do a resection of the right colon The cecum was replaced and the peritoneum sutured

Following operation the stools were repeatedly studied for amebae, Bagen's bacillus and tubercle bacillus, none were found I emphasize the fact that we looked especially for amebae because we had seen marked cecal deformity due to amebiasis

This patient has been under observation for the past six years Occasionally he has discomfort in the right lower abdomen and on two occasions there has been intestinal bleeding He feels well, has had no medical treatment and has refused further surgery I would like to show the roentgenogram of the cecum The original films taken in 1937 have, unfortunately, been destroyed This film was made six weeks after he left the hospital but is similar in character to the one taken ten days after operation

DR ROGER G DOUGHTY, Columbia, S C In listening to Doctor Rosser's paper I was reminded of some cases which occurred in my work some years ago I must apologize for not having accurate data to present Doctor Rosser tells me these cases are extremely rare

One patient in particular, about 60 years of age, had a long history of difficulty with the intestinal tract He had been accused of amebic dysentery but it had never been demonstrated He had also been under medical treatment for various intestinal upsets, labeled with various names When I saw him he had what I took to be an acute appendicitis He was sent to the hospital and, with the usual preparation, was operated upon I was under rather unusual stress because this was the uncle of my wife, a doctor, his son was a doctor and was present I was quite confident that I was dealing with carcinoma We did a resection and end-to-end anastomosis of the ileum

to the stump of the large bowel. The head of the cecum was covered with a small mass of fibrin about 1.5 x 2 cm long. The wall was very much indurated, the area of induration extending over about 6 cm from the base upward, almost completely around the bowel, and the fat tips were indurated.

The report from the pathologist indicated nonspecific ulcer. We sent the specimen to another pathologist who came back with essentially the same report. Because of there having been the suspicion of amebic dysentery we checked the pathology again, and found no evidence that would make either pathologist think it was really an amebic lesion.

Just about three weeks ago another patient came with what I thought was acute appendicitis. Again we opened the abdomen and found a normal appendix. About opposite to the ileocecal valve was a moderately thickened area in the cecum. When we wiped the cecal wall with gauze it stippled. We took the appendix out, closed the wound and the patient was sent back to bed, she was relieved of her symptoms. These things must have a beginning, and Doctor Rosser's paper makes me wonder if I stumbled on the beginning of a benign ulcer.

DR R. L. SANDERS, Memphis, Tenn. Doctor Prioleau has raised an interesting point in reporting his two cases of massive resection of the small bowel. He has shown that a large portion can be removed without altering its function or materially endangering life. This has likewise been true in our experience. I recall one patient, a woman, age 74, who came to us for acute mesenteric thrombosis. We removed more than six feet of the small bowel. She recovered completely and has had no functional difficulty since the operation, now eight years ago.

The essayist also stated that one of his patients developed a troublesome fistula following a complementary enterostomy proximal to the anastomosis. Formerly, we had one or two cases in which a similar complication developed, and a few others wherein the bowel became adherent at the site of the enterostomy, resulting in intestinal obstruction. During the past several years, however, we have obviated these possibilities by omitting enterostomy in all our resections of both the small intestine and the right half of the colon. After reestablishing the continuity of the bowel by an end-to-end or side-to-side anastomosis, we have done nothing more. The use of a simple indwelling tube, as advocated by Wangensteen, has sufficed to prevent postoperative distention and consequent tension on the suture line.

DR J. M. T. FINNEY, Baltimore, Md. These so-called massive resections of the small intestine may at times be multiple. I have a patient upon whom I operated about three months ago, who, seven years ago had about five feet of terminal ileum resected by another surgeon because of a mesenteric thrombosis. About three months ago I was called in and resected three feet eight inches of the remaining ileum because of gangrene due to volvulus caused by adhesions from the previous operation. This makes a total resection of approximately nine feet in two sittings. She is perfectly all right, and much to my surprise does not have diarrhea.

SURGICAL INDICATIONS IN DISEASES OF THE COMMON BILE DUCT*

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SURGERY of the bile ducts has, within recent years, assumed a new aspect. Much of the progress in this field has been due to a better understanding of surgical principles and the indications for exploration. Further, a more accurate determination of the pathologic condition within the ducts has been made possible by cholangiography, and many of the hazards of operation have been reduced by the use of vitamin K and the sulfa drugs. Despite these facts, the mortality of surgical procedures on the ducts remains high, largely because of the almost universal association of disease of these structures with advanced cholecystitis and liver damage. We may look forward to the time when an operation upon the ducts will be a comparatively rare incident because of early surgical termination of gallbladder lesions, but until then we can only continue to apply the principles of good surgery to the individual case and make the best possible use of the therapeutic adjuncts at our command.

The chief conditions for which operations on the ducts are performed are 1 Stones 2 Carcinoma 3 Stricture 4 Pancreatic lesions.

In this discussion, no attempt will be made to describe in detail the clinical picture of each of the foregoing pathologic conditions. Instead, our own experience with duct disease during the past eleven years will be presented, including our conception of the indications for choledochotomy, our methods of management, and the results obtained.

During these eleven years, we have performed 596 operations upon the biliary tree, 575 of this number having been for benign disease of the gallbladder and ducts. Of the 575, 538 were primary operations and 37 were secondary. The ducts were opened and explored 77 times, or 13.4 per cent of the 575. Sixty-one of the choledochotomies were primary and 16 were secondary. There were 17 fatalities, or 3.4 per cent following the gallbladder operations without exploration of the ducts. Compared to this, there were eight fatalities, or 10 per cent, following cholecystectomy or cholecystostomy with choledochotomy. Thus, the mortality rate was almost three times higher in the latter group. These findings are shown in Table I.

Of the 575 operations, stones were found in the gallbladder in 328, or 57 per cent, and of the 77 choledochotomies, duct stones were found in 54, or 70 per cent, as will be seen in Table II.

The mortality rate from the choledochotomies wherein stones were found was 6.8 per cent as compared to 2.8 per cent for those in which no stones

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SURGERY OF THE CHOLEDOCHUS

TABLE I

OPERATIONS IN 575 CASES OF GALLBLADDER AND DUCT DISEASE

		Mortality
Primary gallbladder operations without choledochotomy	477	15 (3.1%)
Secondary gallbladder operations	21	2 (9.5%)
Total	498	17 (3.4%)
Primary gallbladder operations with choledochotomy	61	4 (6.5%)
Secondary choledochotomy	16	4 (25%)
Total	77	8 (10%)

TABLE II

INCIDENCE OF DUCT STONES IN 575 OPERATIONS FOR GALLBLADDER AND DUCT DISEASE

Gallbladder operations	575
Stones	328 (57%)
Duct operations	77 (13.4% of 575)
Stones	54 (70% of 77)

were recovered. We do not believe, however, that the presence of stones has any bearing upon the outcome except insofar as they are usually associated with long standing disease.

In an attempt to compare the number of our choledochotomies and findings of duct stones with those of other surgeons, we have compiled a few figures from reported series (Table III).

TABLE III

	Total Ops	Choledochotomy	Duct Stones
Allen and Wallace (4 years)	266	159 (59.7%)	61.6%
Cutler and Zollinger (5 years)	397	145 (36.5%)	51%
Glenn (6 years)	907	100 (11%)	55%
Heyd (13 years)	3,306	260 (7.7%)	86%
Lahey Clinic (32 years)	3,373	1,292 (38.3%)	37%
Mayo Clinic (1 year)	812	182 (22.3%)	60%
Sanders (11 years)	575	77 (13.4%)	70%

The series reported by Cutler and Zollinger, Glenn, and Heyd were all hospital cases, whereas the remainder were private clinic cases. In this connection, Cattell reports that in the Lahey Clinic during the four-year period of 1938 to 1941, the common duct was explored in 444 of 909 gallbladder cases, or 48.8 per cent, and stones were recovered in 128, or 29 per cent of the explored group, and 14.1 per cent of the 909. Further, during the year 1942, they explored the duct in 130, or 45.3 per cent, of 287 gallbladder cases, but found stone in only 28, or 21 per cent of the 130 choledochotomies, and 9.8 per cent of the entire group of 287 cases.

Until a few years ago, our criteria for openly exploring the ducts in cholecystic disease consisted largely of the palpation of a stone and jaundice. Lately, however, we have been guided by the following findings: 1. Palpation of a stone in the duct. 2. Jaundice, or a history of jaundice. 3. A contracted gallbladder. 4. Abnormal dilatation of the ducts. 5. Aspiration of flocculent bile from the duct.

For purposes of comparison, and to show our more recent experience, we have divided the total of 538 primary gallbladder operations as shown in Table I (477 without choledochotomy and 61 with choledochotomy), and the 37 secondary operations (21 on the gallbladder and 16 on the ducts) into two groups. Those performed prior to June, 1941, being 383 in number, and those performed since that date, numbering 192.

TABLE IV
COMPARATIVE REVIEW OF 575 GALLBLADDER AND DUCT OPERATIONS

	Gallbladder Operations	Gallstones	Duct Operations	Duct Stones
Group I 10/1/32-6/1/41	383	215 (56%)	35 (9% of 383)	26 (74% of 35)
Group II 6/1/41-10/1/43	192	113 (59%)	42 (21% of 192)	28 (66% of 42)
Total	575	328	77 (14.3%)	54 (70% of 77)

Our mortality in the first group was 5 per cent, in the second group, 3.1 per cent.

As will be observed, in the first group our duct operations were considerably fewer in proportion than in the second group, being 35, or 9 per cent of the 383 gallbladder operations performed over a period of almost nine years. In the second group of 192 operations within a little more than two years, we have openly explored the duct in association with operations for cholecystitis 42 times, or 21 per cent. In the first group, stones were found in 74 per cent of the 35 choledochotomies, whereas they were found in 66 per cent of the second group of 42. Although the percentage of choledochotomies was much higher in the second group, the percentage of stones was less. The 28 duct stones in Group II represents approximately 15 per cent of the 192 cases of cholecystitis and 25 per cent of the 113 in which stones were found.

From this experience, we do not see the necessity of subjecting patients to choledochotomy, even though the risk is small, without clear indications. Some surgeons regard dilatation of the ducts as sufficient indication for exploration. In all our operations for cholecystitis we have routinely examined the ducts visually as well as by palpation, with the exception of a few cases wherein the process was too acute and edema too extensive to permit, and have found the common or hepatic duct or both dilated in almost 80 per cent. In 150 of the 192 cases in Group II, some degree of duct enlargement was observed, though in only 113 were gallstones recovered. The ducts, therefore, were enlarged in many cases wherein stones were not even present in the gallbladder.

Obviously, considerable discrimination must be used in performing choledochotomy when a dilated duct is found. The palpation of a stone and jaundice have been our primary indications. As is well known, however, jaundice is an unreliable sign of stone. Past or present jaundice was a finding in only 38, or 50 per cent, of our cases in which duct stones were recovered. Jaundice,

or a history of jaundice, was a factor in 86 per cent of the remaining choledochotomies, and in approximately half of these the duct was dilated because of an associated pancreatitis, usually with a more or less extensive hepatitis. Occasionally, also, we have opened a dilated duct in the presence of jaundice, only to find no explanation for the obstruction other than a possible spasm of the sphincter of Oddi.

In the absence of jaundice and a palpable stone, our criteria for opening dilated ducts have been the discovery of a contracted gallbladder, small stones in the gallbladder with an enlarged patent cystic duct, the presence of flocculent bile in the ducts as determined by aspiration, and a history of chills and fever. Not infrequently, however, the common duct is abnormally dilated incident to occlusion of the cystic duct with a stone in long-standing gallbladder disease, the duct having taken over the function of the gallbladder. The bile being clear, there is no point in choledochotomy. We have also observed a few cases in which the duct was dilated from obstruction by an enlarged node, an anomalous artery, or by adhesions. In these, removal of the obstruction has been sufficient to relieve the condition.

Some degree of hepatitis or pancreatitis, unassociated with jaundice, has been encountered in a high percentage of the cases of this entire series. As a rule, we do not open the duct in such cases, believing that the inflammatory process will subside following cholecystectomy alone. Our results have borne out the wisdom of this view.

Duct stones were recovered in ten of the 16 secondary operations on the ducts. The obstruction was caused by adhesions in one case, by stricture in three, by pancreatitis in one, and in one case apparently by spasm of the sphincter.

Of the 16 secondary operations, the primary procedure was carried out elsewhere in 12 cases and by us in four. One of the latter was in the second group of Table IV. In this case, at the first operation numerous bile cysts were found in the liver and the common duct was as large as the duodenum and filled with dark, sandy bile. The distal end of the duct was dilated to the size of a No. 7 dilator and drainage instituted. Nevertheless, stones were subsequently formed in the liver in such quantities as to pack the ampulla, necessitating a second choledochotomy and anastomosis of the duct to the duodenum in order to promote complete emptying of the bile passages.

Within recent years we have made a practice of dilating the lower end of the duct to almost normal size with Bakê's dilators, when possible. No untoward postoperative effects have been observed. Combined with thorough exploration of the ducts, lavage and the use of the T-tube, and medicinal measures to stimulate bile drainage, this procedure has been ample to insure the patient against further trouble, with the above one exception. We have not considered it necessary to make cholangiograms at the time of operation, though we do so before withdrawing the T-tube when such a procedure seems indicated.

In this connection, I wish to call attention to an incident which has happened

more than once in our experience, and which has a possible bearing upon secondary operations for stones in the duct. In one case, the common duct was opened and explored, stones were removed, and the duct irrigated with salt solution before the cholecystectomy was begun. While the gallbladder was being manipulated, small stones slipped through the cystic duct into the common duct under sight, necessitating a second irrigation of the duct. In another case, the common duct was opened and evacuated of stones, and the T-tube sutured in place. The gallbladder, which contained a large number of small stones, was then removed. The cystic duct was patent and fairly large. The tube did not drain well, and it was necessary to reopen the duct and withdraw the tube. It was then found that three or four stones had passed through the cystic into the common duct. A subsequent operation might have led us to believe that the stones had reformed in the duct. Since these experiences, we have removed the gallbladder before doing the choledochotomy, thus, we can be assured that the common duct is entirely free of stones at the conclusion of the operation. If, later, it should be necessary to open the duct because of stones, we can be certain they have been formed subsequently, and are not stones which were overlooked at the first procedure.

Three patients of this series, or 0.5 per cent, came to operation for partial stricture of the duct, all following surgery. Two of the three had been operated upon by us. In one of these cases, the stricture was induced by clamping of the duct in an attempt to control hemorrhage from a necrotic, ruptured cystic artery which paralleled the duct. A choledochotomy was done and the distal end of the duct dilated. The patient has since remained well.

The partial stricture in the second case was the result of a narrowing of the duct at the site of a former choledochotomy. Three years had intervened since the operation and the liver had become involved in an advanced cirrhosis. The duct was widely explored and drained. The patient succumbed two weeks later from liver and kidney dysfunction.

The third patient had had a partial cholecystectomy elsewhere. At the second operation, the cystic duct had become enlarged, forming a miniature gallbladder, and was filled with stones, the distal end of the common duct was strictured, and a severe pancreatitis was present. The gallbladder was removed, the duct opened and explored, the distal end dilated and drainage instituted. The patient is still free from symptoms, now more than a year since the operation.

By far the majority of duct strictures arise from operative trauma incident to clamping of the ducts in an effort to control hemorrhage from an accidentally injured artery. Such accidents are especially likely when the ducts and arteries are abnormally situated. We have encountered anomalies of these structures in fully 50 per cent of our cases. One can thus readily appreciate the necessity for adequate exposure and meticulous care in their manipulation. The second of the above cases, though not itself the result of actual trauma, presents an illustration of the possible consequences of even partial stricture.

The common duct is one of the rarest of locations for malignant disease. In Heyd's series of 3,986 biliary tract operations, duct carcinoma was encountered only five times. Two, or 0.3 per cent, of the patients in the present series of 596 had carcinoma of the common duct. One, a man, age 68, gave a history of gallbladder symptoms for 30 years, and had recently developed a deep jaundice, but without chills and fever and without pain. The gallbladder was distinctly palpable. The preoperative diagnosis was carcinoma of the pancreas or duct, with possible extension to the liver. At operation, the tumor was found in the common duct at its junction with the cystic, and extending backward into the liver. The gallbladder was enormously distended with dark bile but was not diseased, and since the hepatic duct was apparently patent, a cholecystogastrostomy was performed. The patient lived but a short while after leaving the hospital.

The second patient, a woman, age 71, also gave a history of long-standing gallbladder disease and recently abdominal distress and increasing jaundice, but without chills. The gallbladder, however, was not palpable. The preoperative diagnosis was cholecystitis with stones and probably stones in the duct. On opening the abdomen, there was an extensive carcinoma in the midportion of the duct. A part of the growth was encroaching upon the gallbladder and liver. The gallbladder had perforated into the liver, evidently a long while previously, and a number of stones were contained in the pocket. As much of the growth as possible was excised, an hepaticoduodenostomy performed, and the gallbladder drained. This patient, also, died at home after a few weeks.

It will be observed that the location of the carcinoma in both the above cases precluded the use of the Whipple operation. We have, therefore, had no occasion to employ this procedure.

In the first case, the painless, rapidly progressive jaundice and the palpable gallbladder were typical of carcinoma. In the second, the diagnosis was obscured by the presence of gallstones. No duct stones were found in either case. These experiences tend to bear out the observation of other surgeons that, apparently, there is no direct association of duct stones to carcinoma of the ducts such as is observed between gallstones and carcinoma of the gallbladder.

On the whole, the prognosis for carcinoma of the ducts should be better than for carcinoma of the gallbladder or the intestinal tract in that patients come to operation early on account of obstruction. This was not true of either of the above cases, however, wherein the growths were extensive despite the fact that definite evidence of obstruction had been present only a few weeks.

We have had two occasions to do a choledochoduodenostomy for carcinoma of the pancreas, the gallbladder having been previously removed in both cases. In an additional 12, cholecystogastrostomy was carried out. There were no hospital deaths in any of the group of 14.

COMMENT

With few exceptions, the object of operations upon the ducts is release of obstruction by a stone, and in our opinion one is not justified in adding choledochotomy to the already severe handicap of these patients without ample evidence of stones. It is agreed that when a stone is palpable, the patient is jaundiced or has a history of jaundice, or chills and fever, and the common duct is abnormally enlarged and thickened, when there are stones in the gallbladder and the cystic duct is dilated, or flocculent bile is present in the duct, pointing to a possible impalpable stone in the ampulla, then choledochotomy is definitely indicated. Mere dilatation of the common duct however, is not in itself an indication. In many cases, the dilatation is physiologic, being due to a dysfunctioning gallbladder. In others, it is due to extrinsic mechanical obstruction. In still others, it is secondary to a gallbladder infection and is amenable to relief by cholecystectomy alone. Nor do we share the view that hepatitis and pancreatitis are, generally speaking, indications for exploration of the duct. As a rule, these conditions will subside following removal of the gallbladder.

It appears that the finding of duct stones varies in the experience of different surgeons, and from time to time in the experience of the same surgeons. In our own experience, the age incidence of patients who have come to surgery for cholecystitis within recent years has been materially lower. The incidence of stones in the gallbladder has consequently been less as patients are operated upon at an earlier age. We are, however, operating upon a larger number of patients for cholecystitis with stones and a smaller number for noncalculous cholecystitis. Thus, our percentage of gallstones remains practically unchanged. One would naturally expect that, in younger patients who have had stones in the gallbladder for a shorter period, the incidence of duct stones would be reduced and there would be a corresponding reduction in the number of choledochotomies. We believe this explains the lower incidence of duct stones in proportion to the number of explorations in our cases within recent years. Should the practice of operating upon patients earlier continue, as it no doubt will, it should lead, not to more, but to fewer choledochotomies in the future.

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CHOLESTEROLOSIS ITS SIGNIFICANCE IN THE BADLY DAMAGED GALLBLADDER*

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THE CLASSICAL FORM of cholesteriolosis of the gallbladder generally manifests itself by a submucosal deposit of esters of cholesterol chiefly in histiocytes. These deposits are often focal in character producing the gross appearance of a small yellow elevation when the mucosa is inspected in the fresh specimen. The histiocytes become large and foamy and are associated with a club-like enlargement of the villi. While these histiocytes represent true xanthoma cells, this phase of cholesteriolosis is but rarely associated with giant cell reaction and fibroplasia as is often the case with focal xanthomatous reactions in other organs. The so-called "strawberry gallbladder" is commonly found associated with cholesterol stones and as such is of great clinical importance. Cholesteriolosis, itself, however, has less surgical significance chiefly because of the lack of association with any great degree of inflammation in the wall of the gallbladder and thus its failure to produce severe symptoms.¹

Because of its unique clinical and pathologic picture, cholesteriolosis has been placed in a separate category in the classification of lesions of the gallbladder. Whereas, in times past there have been many who have considered cholecystitis primarily an infectious disease, there have been few who would deny that cholesteriolosis is truly a metabolic disease—a chemical cholecystitis.

Where gallstones have been present for some time it is not unusual to find a gallbladder showing evidence of cholesteriolosis and at the same time the more common type of fibrous cholecystitis. We are thus often confronted with a picture of cholecystitis when the two types of inflammation have definitely merged into one, that makes such a dual concept of pathogenesis awkward.

In several recent publications² we saw reason to doubt the frequency of primary bacterial cholecystitis and presented experimental evidence to show that other forms of cholecystitis than that of cholesteriolosis or strawberry gallbladder may also be primarily chemical. Where an infectious process is present we have suggested that this exists as a secondary invasion of previously damaged tissue rather than as a primary bacterial infection. We called attention to the fact that bile itself is damaging to tissue. It sets up an inflammatory process of a type similar to that seen in cholecystitis. It produces a marked increase in capillary permeability in the region in which it was placed. This is first evidenced by edema but later there may be even diapedesis of red blood cells and ecchymosis. Following the alteration in capillary permeability one sees definite local tissue damage in the form of actual gangrene or a lesser

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damaging effect This inflammatory process is associated with a cellular reaction which is chiefly lymphocytic and histiocytic although a few polymorphonuclear leukocytes may be present The severity of this inflammatory reaction produced by bile seemed to be in direct proportion to the concentration of cholesterol and bile salts

Because of the similarity between such local effects of bile in tissue and the pathologic picture seen in the human in acute cholecystitis, we suggested that bile itself when imprisoned in the gallbladder by obstruction of the cystic duct, may set up such an inflammation in the gallbladder wall as to produce a characteristic pathologic picture of cholecystitis

We were able to demonstrate that in dogs complete obstruction of the cystic duct did not produce inflammation of the gallbladder if the imprisoned bile is withdrawn and replaced by an equal amount of physiologic solution of sodium chloride However, if bile were left imprisoned in the gallbladder and the cystic duct obstructed, inflammation of the gallbladder wall did take place and the severity of this inflammation was apparently in direct proportion to the nature and the concentration of the bile obstructed Where this concentration was as much as one time actual necrosis of the gallbladder was frequent If the obstruction of the cystic duct was not present, then the injection of such concentrated bile failed to produce any evidence of damage to the gallbladder wall The substances in bile chiefly responsible for such injury appeared to be cholesterol or some of the bile salts Of the latter group sodium taurocholate, sodium glycocholate and sodium desoxycholate were studied The latter seemed to be the most damaging

From these studies it seemed to us fair to conclude that three important factors were involved in the production of cholecystitis These factors were obstruction of the cystic duct, the action of bile on the gallbladder wall, and the occasional secondary presence of bacterial infection which would be superimposed upon the chemically damaged tissue While the bacterial infection is often so great as to overshadow all of the other factors, in all probability it is usually preceded by the chemical damage

As most of the bile products that produced the changes in our experimental animals were related to cholesterol and cholic acid, it occurred to us that there might be some evidence available in the gallbladder wall of the presence of such material in human cholecystitis Since many of these substances are lipid in character it might be possible to distinguish such substances in the gallbladder wall The most common infectious agents in cholecystitis belong to the streptococcus and colon groups of organisms and one would, therefore, expect a characteristic pyogenic reaction where infections were predominant A reaction to lipid material, on the other hand, would consist generally of edema, fibroplasia and a histiocytic response either as inflammatory cells, xanthoma cells or giant cells

In a previous publication^{2b} we called attention to the existence of such an inflammatory reaction to lipoids in damaged human gallbladders as was sought for above In the present study we wish to expand these findings further

Three hundred fifty-four gallbladders which were removed consecutively at the Barnes Hospital, from January, 1939, to August, 1943, are included in this study. Blocks of tissue were taken from the fundus and neck of the gallbladder. The tissue was fixed for the most part, in 10 per cent formalin solution within a few minutes after it was removed from the patient. The sections were cut and stained with hematoxylin and eosin. Occasionally Foot's modification of Masson's trichrome stain was used. Where microscopic evidence of lipids was seen both scharlach R and sudan III stains were

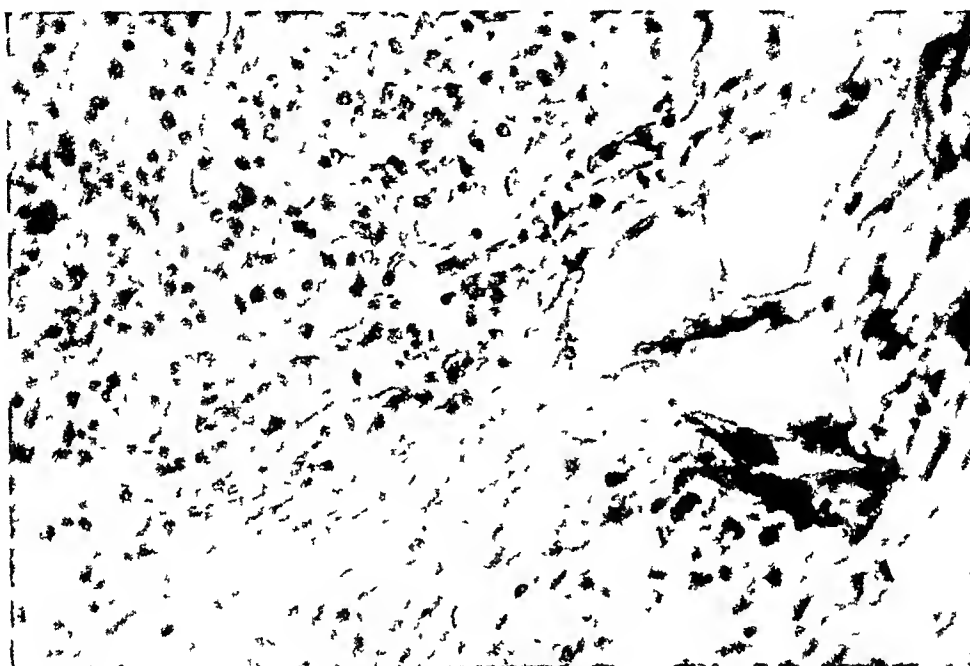


FIG 1.—Histiocytes filled with what is apparently cholesterol ester and located deep in the wall of the gallbladder. Note the dense fibroblastic reaction.

used. Where it was thought necessary to use polarized light the material was previously prepared by incubation from three to six hours in digitonin.³

In 36 cases, or 10.2 per cent of our specimens, lipid material resembling cholesterol ester was found in histiocytes beneath the mucosa giving the characteristic picture of strawberry gallbladder. This, as a rule, was associated with but little damage to the gallbladder wall and was in most instances found in conjunction with cholesterol gallstones. In 80 cases, or 20.6 per cent of our material, there was microscopic evidence of either lipid or bile deep in the gallbladder wall. In almost every instance these gallbladders were badly damaged, most of them showing evidence of recent acute inflammatory reaction. Including cholesterolosis or strawberry gallbladder, therefore, this gave a total of 116 cases, or 32.8 per cent of the gallbladders removed, showing some histologic evidence of lipid or bile reaction in the wall.

An effort was made to identify the type of lipid present by histochemical means. There was, however, such considerable variation in the staining reactions that accuracy in the identification of the lipids was questionable. In some of the instances edema of the gallbladder wall seemed to be partly

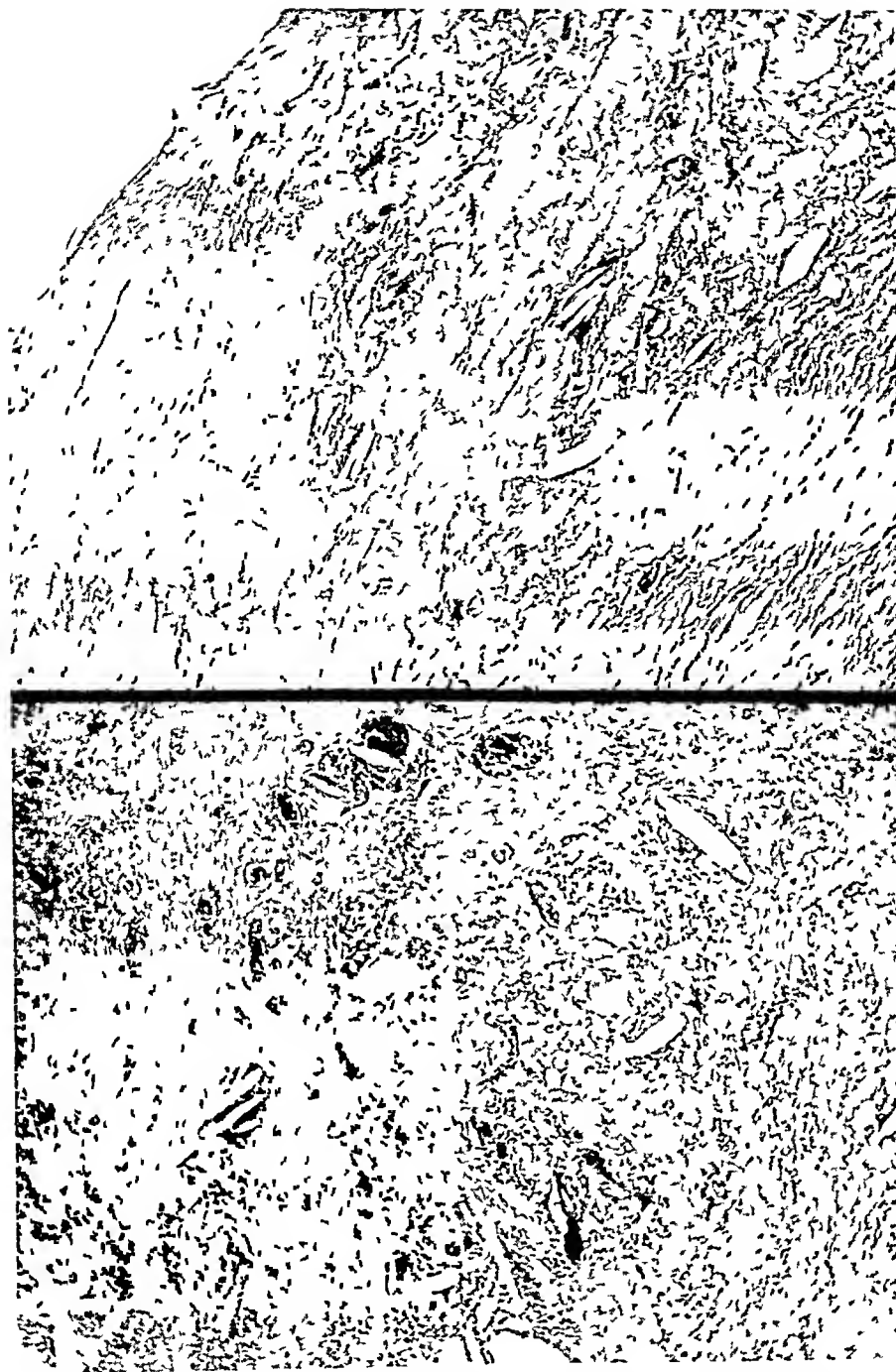


FIG 2—(a) Intracellular and extracellular cholesterolosis of the gallbladder wall. The latter apparently exists here as free cholesterol.
 (b) What is probably an older phase of the same type of reaction as that shown in 2a. Note the increasing fibrosis and the giant cell reaction around the cholesterol crystals.

responsible. At other times the reason was not obvious. Thus, while we are considering most of these lipids as a form of cholesterolosis, it must be borne in mind that there is a possibility that some of them may not be of cholesterol origin. This, of course, is taken for granted where what is apparently desiccated bile is found. Certainly some of the lipids had their origin from red blood cells as could be determined by adjacent stainable iron in the tissue.

Perhaps the most common finding was that of lipid esters, presumably cholesterol esters in the cytoplasm of histiocytes resembling those found in the submucosa in strawberry gallbladder. Figure 1 illustrates such a finding. The cells present a granular, vacuolated or reticulated cytoplasm with a round or kidney-shaped nucleus in an eccentric position. The cells tend to be arranged in no particular architecture but exist as a focal conglomerate in a sheet-like form. In the fresh gross specimen these could often be seen as small yellow bodies, not a great deal unlike those seen in the strawberry gallbladder.

As a general rule, there was a considerable amount of fibroplasia generally seen around such areas of xanthomatosis. Where there was no evidence of extracellular accumulation of lipids the tissue reaction was generally not so acute. One of the most common of such extracellular substances apparently was free cholesterol. This is illustrated in Figures 2a and 2b. In these gallbladders one sees the same type of xanthomatous reaction as observed in Figure 1, along with slits and crevices representing spaces formerly occupied by what apparently were cholesterol crystals. Around such spaces one sees a giant cell reaction and lymphocytic invasion. Such a picture can be interpreted as a reaction of tissue to free cholesterol and to its esters.

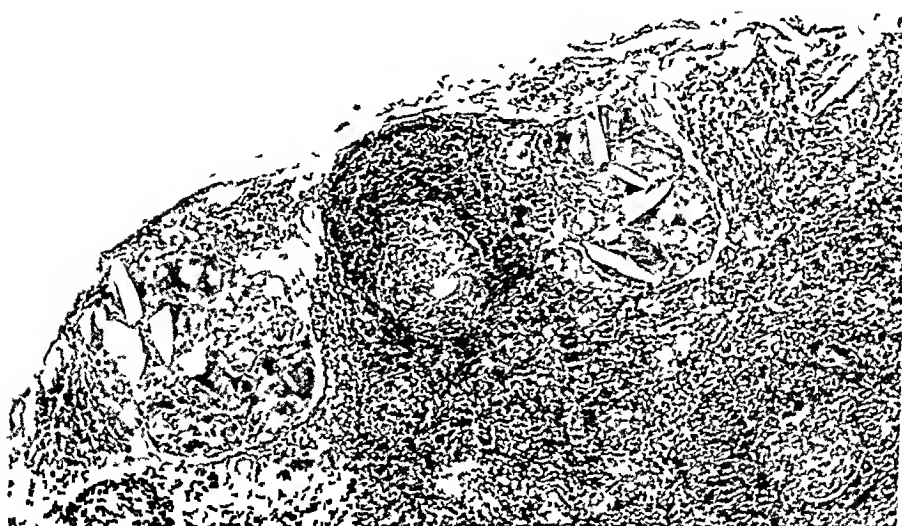
It was not an unusual finding to encounter deposits of what apparently was free cholesterol in the gallbladder wall not associated with a considerable xanthomatous reaction. Figure 3a illustrates such a lesion. It will be noted that the deposit is just external to the musculature in the subserosa. This was not an infrequent location of this material. Such deposits, in fact, were probably more frequently encountered in the subserosa than in the submucosa. One of the interesting features about this particular specimen was the metastasis of the cholesterol to the regional lymph node at the junction of the cystic and common ducts. This is illustrated in 3b. These regional lymph nodes were not examined frequently enough microscopically to allow any statement as to how often such a phenomenon occurs. We observed it in only two instances in this series.

Xanthomatosis also often occurred in association with clear, irregular deposits of a brilliant orange-colored substance having all of the characteristics of the color of bile. This we have considered an extravasation of bile into the gallbladder wall. Where it was found associated with xanthomatosis the tissue reaction was often violent. Figure 4a shows such a reaction. In the upper right corner one may see the deposits of bile existing as dark, homogeneous, gray areas surrounded by histiocytes. At the lower left the serosa is edematous and contains a considerable number of polymorphonuclear leukocytes. This section is taken through the serosa and subserosa. Figure 4b gives an older reaction of a similar type taken through the gallbladder wall near the serosa in another specimen. The bile has become much darker in color and the inflammatory reaction shows a much older type of fibroplasia.

What apparently are deposits of bile may occasionally be encountered in the gallbladder wall without an associated xanthomatous reaction. Figure



(a)



(b)

FIG 3—(a) Free cholesterol in the wall of a gallbladder with very little xanthomatous reaction and no edema. This is an old process.

(b) Regional (sentinel) lymph node removed along with gallbladder shown in Figure 3(a) demonstrating metastasis of the cholesterol through the lymphatics.

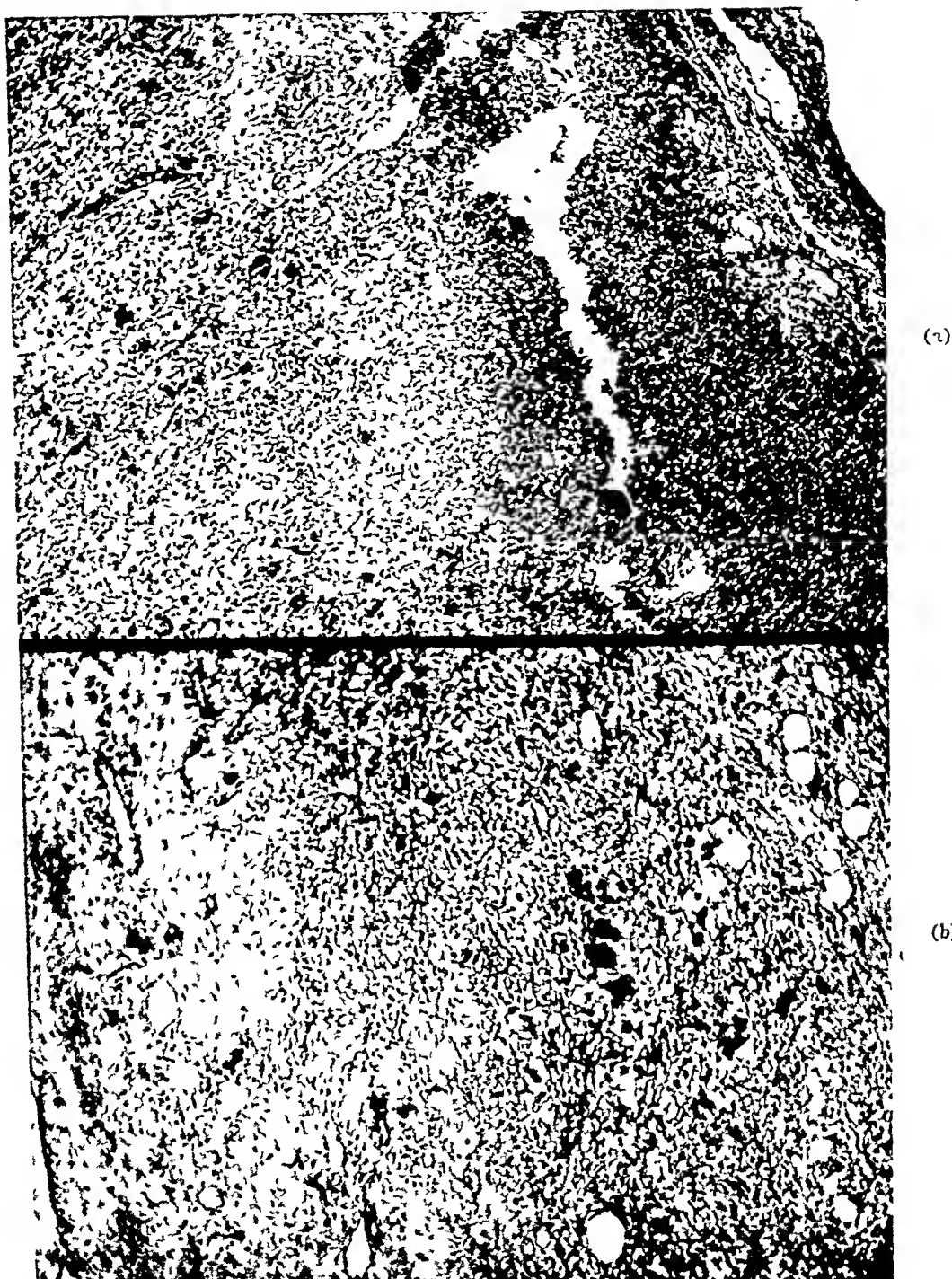


FIG. 4—(a) Deposits of what is apparently bile may be seen in the left of the section surrounded by foam cells. Note the fresh exudate around the serosa.

(b) An older phase than that seen in Figure 4(a). The bile stains deeper, fibrosis is dense and fat replacement is beginning.

5a shows the appearance of such inspissated bile on the mucosa of the gallbladder. It should be noted that the adjacent epithelium is destroyed. Figure 5b shows such deposits of bile in an inflammatory exudate around the serosa of a gallbladder in which there are areas of old blood. In the stained section there was marked contrast between the different types of pigment, the bile being a brilliant orange and the blood a brick red.

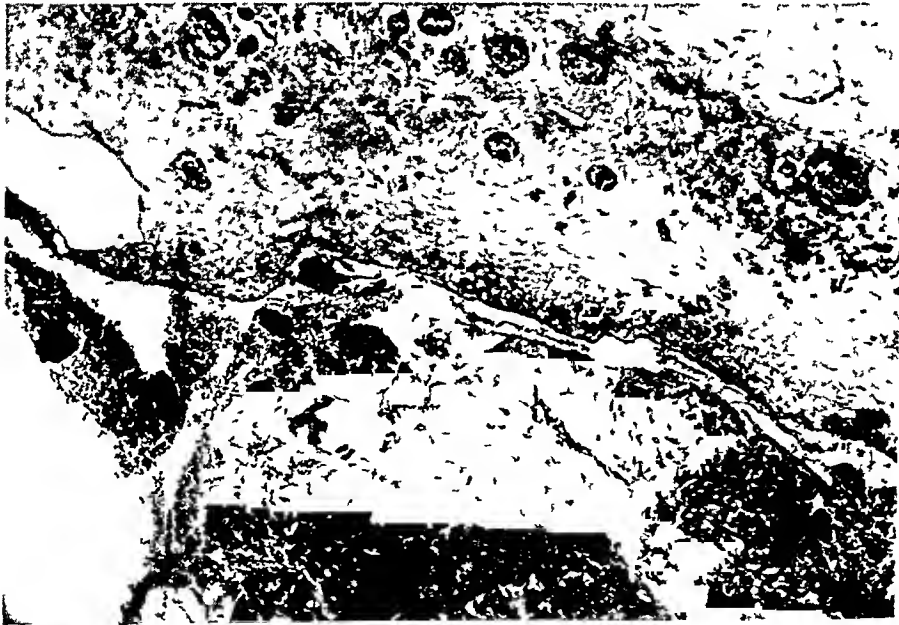
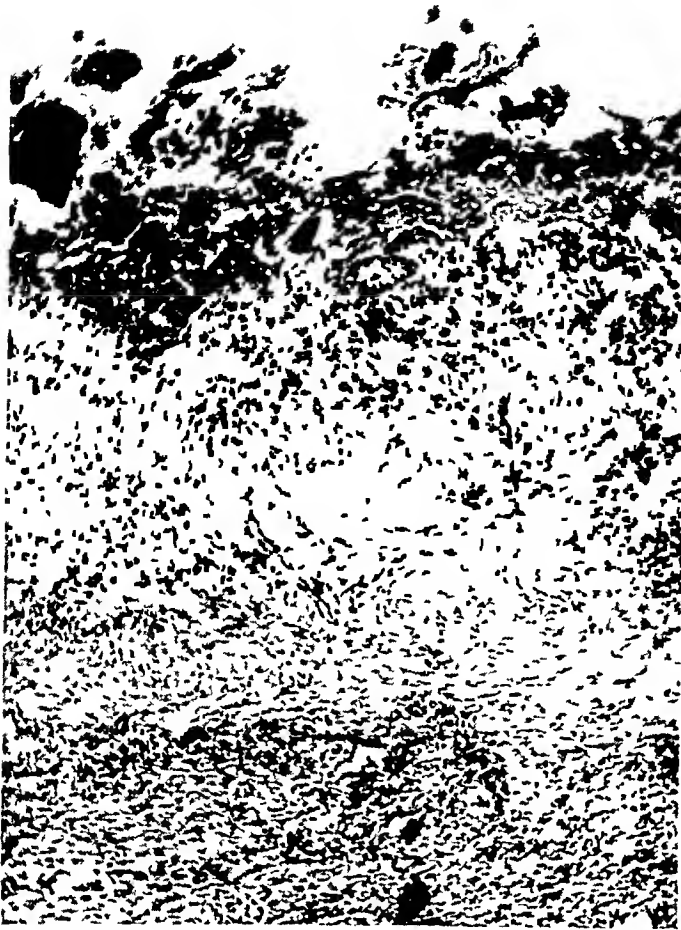


FIG 5 —(a) Deposits of inspissated bile on the mucosa of the gallbladder. Note the destruction of most of the epithelium.
(b) Deposits of bile in a region in which there is old blood. Note the difference in their characteristics.

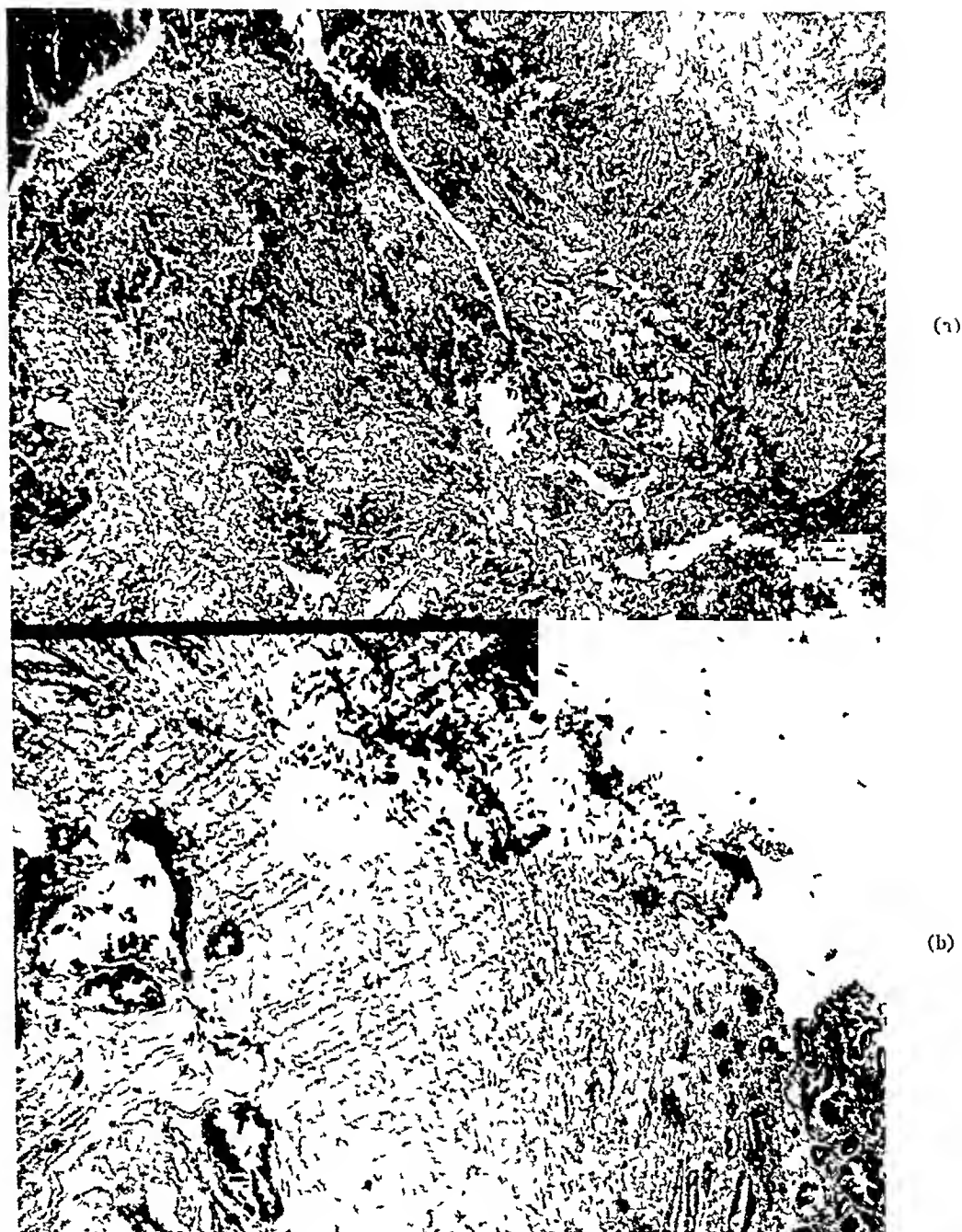


FIG 6 —(a) Large deposit of bile and cholesterol in the wall of a badly damaged gallbladder

(b) A still older phase of bile deposit in a dense, vascular gallbladder wall. What seemed to be calcium salts were beginning to appear in the deposits

Figure 6a shows an older process in which one sees a deposit of bile pigment in which there apparently was a considerable amount of cholesterol. The deposit is surrounded by a very dense inflammatory reaction consisting mostly of fibrosis and histiocytes. Figure 6b shows a much older phase of the same type of reaction. Here one sees several deposits of bile, or what is apparently bile as determined by its color, which have become so hard that the microtome knife was injured, evidence of which can be seen in the section. The fibrous tissue around such deposits is rigid. It is not unlikely that calcium

soaps are deposited in such areas and such a reaction may explain much of the calcification seen in the gallbladder wall on rare occasions

Figure 7 is offered as evidence that the bile reaches the gallbladder wall by extravasation in some way. The lower portion of the section represents a cyst the wall of which is lined by scar tissue. The cyst contained pigmented

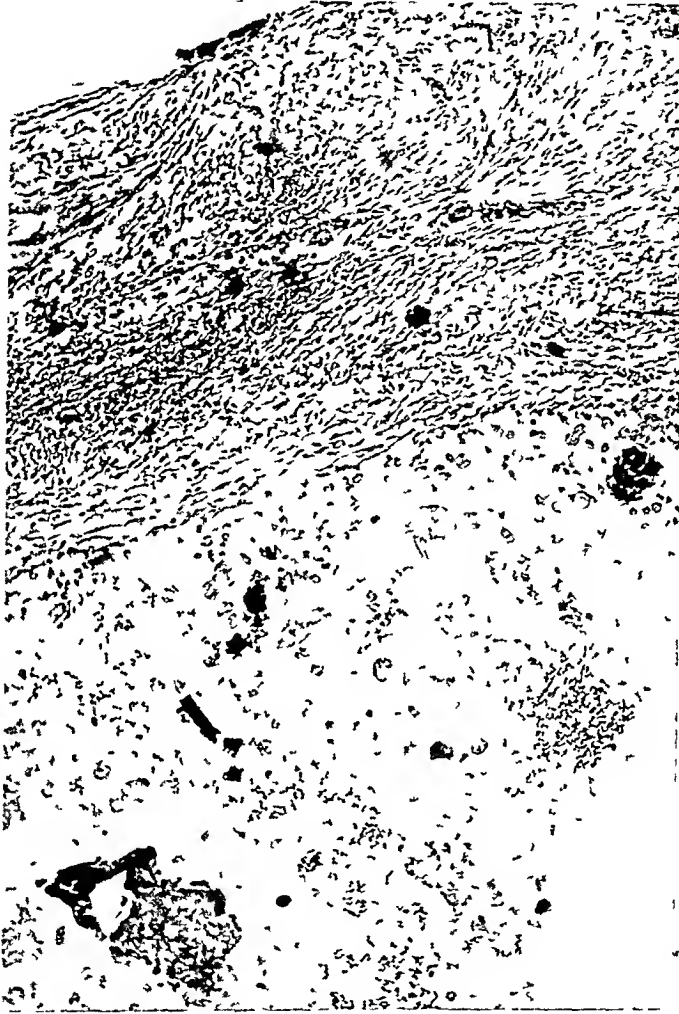


FIG 7—Cyst formation in gallbladder wall. The cyst is lined by scar tissue and contains bile elements

material resembling bile and the microscopic appearance of some of the precipitate is identical to that described in previous sections

Figure 8 is taken from another specimen showing what apparently is the crystallization of cholesterol taking place in the wall of a gallbladder. The striations are easily observed and the beginning giant cell reaction is obvious

SUMMARY AND CONCLUSION

Since from experimental evidence most instances of cholecystitis have their beginning as a result of chemical injury to the gallbladder wall and since the

most likely chemical producing this injury is bile, gallbladders removed at operation for clinical cholecystitis were studied microscopically for evidence of bile or cholesterol in the wall. Three hundred fifty-four specimens removed consecutively for gallbladder disease were studied. Of these 116, or 32.8 per cent, showed some evidence of lipid or bile reaction. In this group is included the so-called cholesterolosis or strawberry gallbladder of which there were 36, or 10.2 per cent. In the remaining 80 cases, or 22.6 per cent of the material studied, there was easily demonstrable in the gallbladder wall evidence of tissue damage due to the presence of what was apparently cholesterol,



FIG 8—Crystallization of cholesterol in gallbladder wall suggesting that it enters the intercellular spaces in fluid form

cholesterol esters or inspissated bile, itself. These substances were almost universally found associated with severe damage to the gallbladder wall. In no instance were they noted deep in the wall in the absence of severe tissue reaction. Some of the most characteristic microscopic pictures are described in detail. These data are offered as additional evidence that bile plays a dominant part in the production of cholecystitis.

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- ³ Cowdry, E. V. *Microscopic Technique in Biology and Medicine*. Williams and Wilkins Co., Baltimore, 1943.

DISCUSSION—DR RAYMOND P SULLIVAN, New York City Doctor Sanders very briefly referred to diseased conditions of the common bile duct, which may be manifested in various types of trouble not only to the patient, but also to the surgeon I refer particularly to strictures and tumors of the common bile duct, which demand reconstruction so as to insure a proper flow of bile into the intestinal tract I now show you some lantern slides of cases illustrating some of these difficult and various conditions

The first slide concerns a woman, age 57, admitted to St Vincent's Hospital, New York City, in May, 1920, because of manifest signs of acute intestinal obstruction At operation the intestinal obstruction was found to be due to a large gallstone impacted in a section of the jejunum The passage of the gallstone was *via* a pathologic cholecyst-enterostomy Removal of the gallstone corrected the obstruction The internal fistula

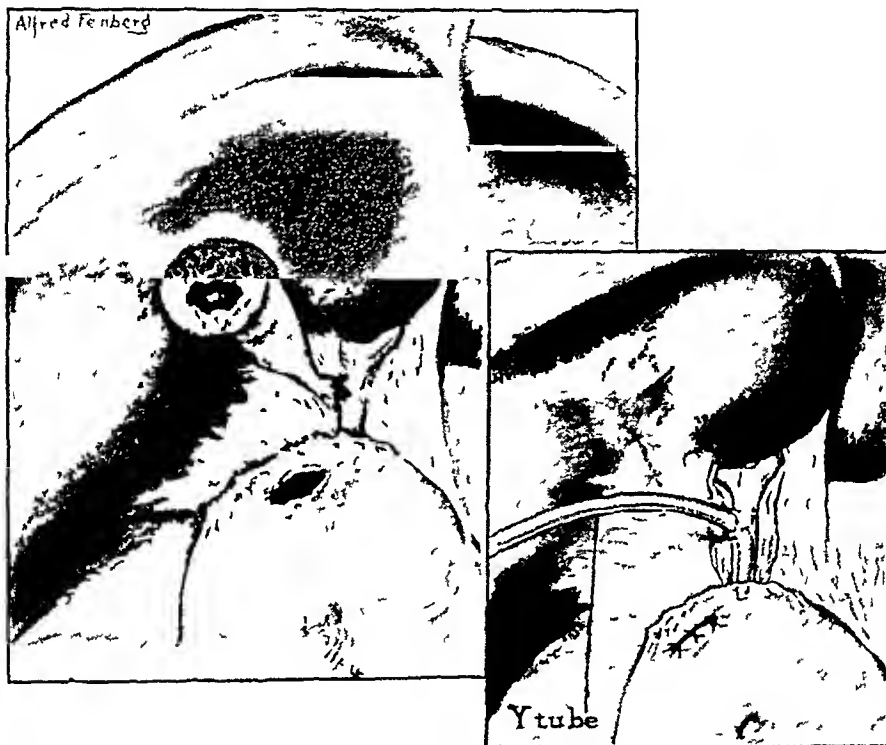


FIG 1—Represents the traumatic rupture of the common duct during cholecystectomy Reconstruction over a Y tube Satisfactory result

demand repair, which was accomplished by separation of fundus of gallbladder from intestine Repair of the intestinal opening was simple Cholecystectomy was complicated by excessive traction on cystic duct sufficient to cause a rupture of the common duct, as demonstrated by the drawing Immediate repair of this common duct was made by splitting a No 16 F rubber catheter for a distance of 25 inches, then introducing the limbs of the resultant Y-shaped rubber tube—in both upper and descending direction of the common duct—followed by closing the duct over the rubber tube by interrupted sutures This worked well Additional small rubber tissue drain placed in subhepatic area was removed in three weeks with satisfactory relief of all symptoms Follow-up examination, in May, 1935, demonstrated freedom of any symptoms referable to bile ducts

The second slide shows the case of a woman, age 33, who had a biliary fistula following cholecystectomy by another surgeon in July, 1931 The fistula resulted from injury to the extrahepatic portion of the common duct at the original operation The procedure, as demonstrated herewith, was to mobilize the fistulous tract, into which a filiform bougie had been introduced, and to visualize the supraduodenal portion of the common duct It was thus learned that a complete fibrosis of most of the common duct existed Accordingly it was necessary to construct a new channel for transmission of bile flow This was done by making a V-shaped full-thickness flap of the anterosuperior wall of the duodenum, then attaching the apex of the flap to the extrahepatic remnant

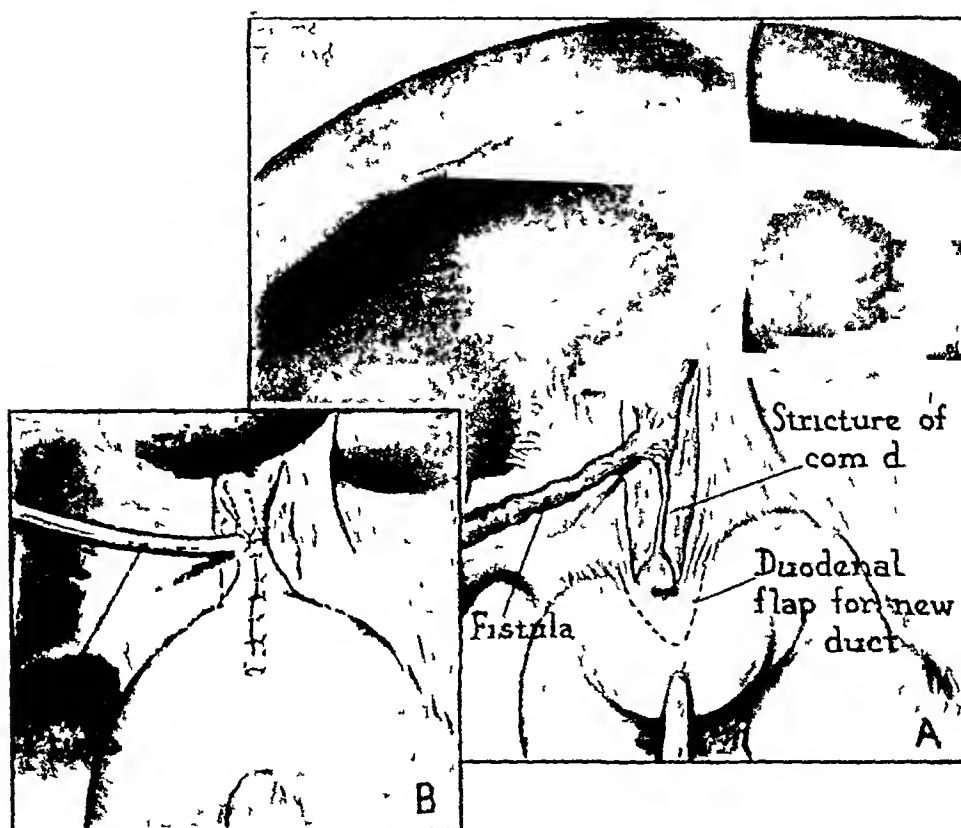


FIG 2—Case of biliary fistula necessitating reconstruction of common duct by full thickness V shaped flap from duodenal wall

of the common duct, placement of a T-tube, and reconstruction of the wall of the duodenum over the limbs of the rubber tube. Secondary support was obtained by closing the periductal tissues over the reconstructed common duct. The result was satisfactory for two years when, following an attack of influenza, jaundice recurred, evidently the result of cholangitis and secondary stricture, as demonstrated by the drawings. Secondary operation revealed a stricture at the site of anastomosis between the duct and the duodenal wall. This area was excised and an indwelling section of a No 16 F catheter was used to reconstruct the common duct. The indwelling rubber tube was held by

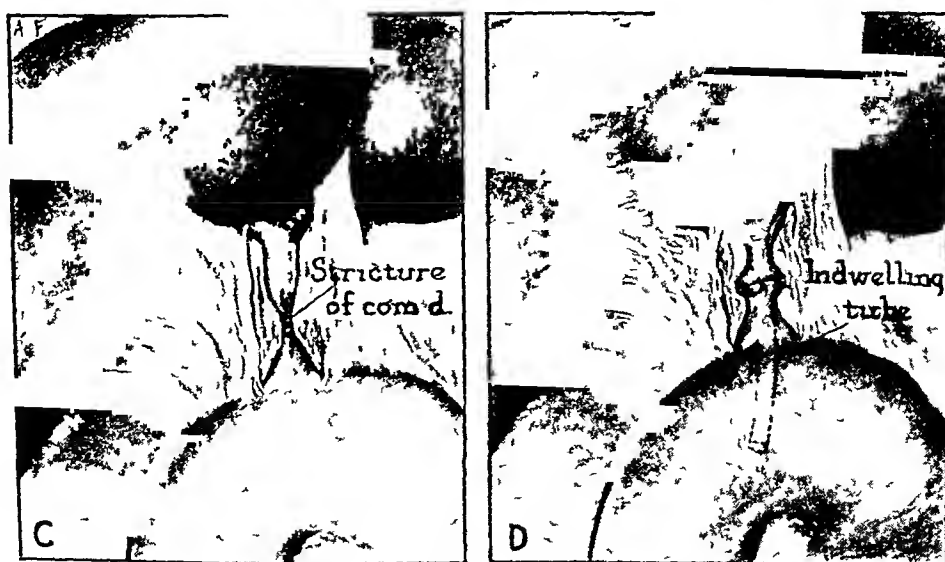


FIG 3—Represents secondary stricture at the site of anastomosis between duodenal flap and common duct. Total excision of stricture over indwelling rubber tube, in residence two years

interrupted silk sutures, with a completely satisfactory result. She was last seen in April, 1943, with no evidence of recurrence of jaundice or common duct symptoms.

The next patient, R. C., a man, age 45, was seen in August, 1937, because of jaundice, weight loss and severe colic. He had had no previous operation. However, he was "gassed" in World War I, and did not suffer from colic followed by jaundice until one year ago. In the past three months the jaundice was persistent and more intense. Operation, August 30, 1937, revealed a thick-walled gallbladder filled with stones and a tumor involving the gallbladder, cystic and common bile duct. The extrahepatic portion of the duct was considerably distended while the supraduodenal portion of the common duct was contracted. Cholecystectomy and removal of the entire cystic duct and the segment of common duct was performed, a T-tube was placed and the common

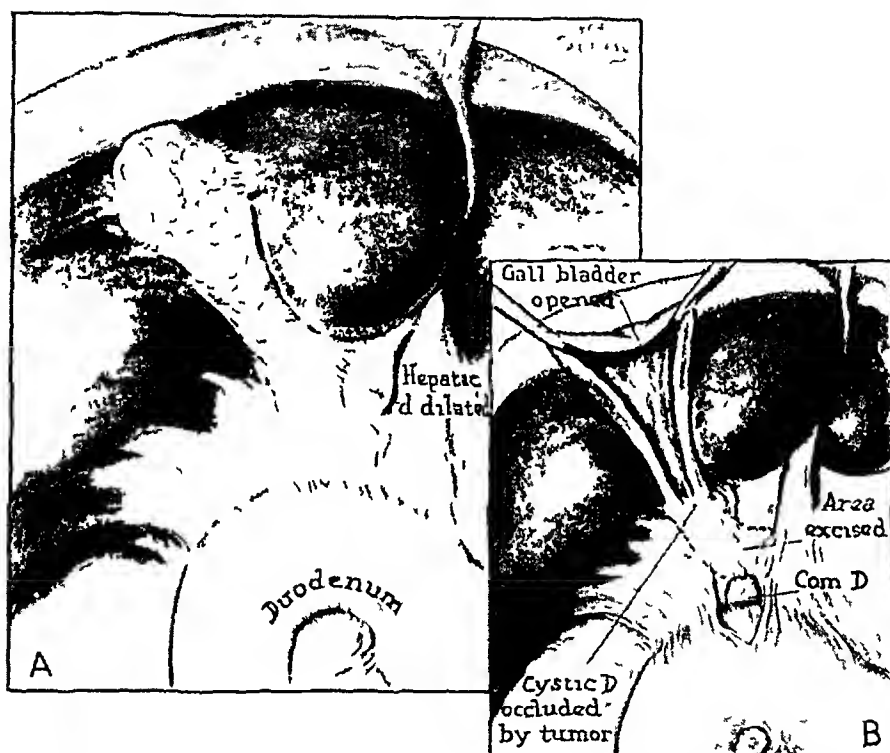


FIG. 4—Represents the tumor of the common duct, associated with cholelithiasis. Involved section of the common duct removed with the gallbladder, in continuity. Reconstruction of common duct over T-tube, in residence eight months.

duct reconstructed using silk sutures. The subhepatic rubber tissue drains were removed on the sixth postoperative day. The T-tube was left *in situ* for eight months. The patient opened the tube every few days to observe the bile flow. He went back to work and the jaundice cleared satisfactorily within two months. Subsequent injection of lipiodol failed to reveal any evidence of stricture or tumor in the biliary tree. Accordingly, the T-tube was removed at secondary operation and an indwelling soft rubber tube was placed in the duct and held with chromic gut sutures. The result has been most satisfactory, and the patient is now serving as an infantry officer in Italy.

The next slide concerns a female (L. S.), age 42, who had had a cholecystectomy and choledochotomy for chronic suppurative cholecystitis and cholangitis in September, 1929. Recurrent symptoms brought her to the hospital in November, 1929. Operation revealed massive adhesions in subhepatic region, the area involved in the previous subhepatic abscess. These dense adhesions were firm enough to constrict the common duct at the site of the previous choledochotomy. This area, as shown by slides, was excised and a soft rubber tube was placed in the common duct and held by silk sutures. The result was very satisfactory, and to date there have been no symptoms. The rubber tube passed out after 14 months residence in the common duct.

The next slide concerns a woman who had had cholecystectomy for calculus disease

CHOLESTEROLOSIS

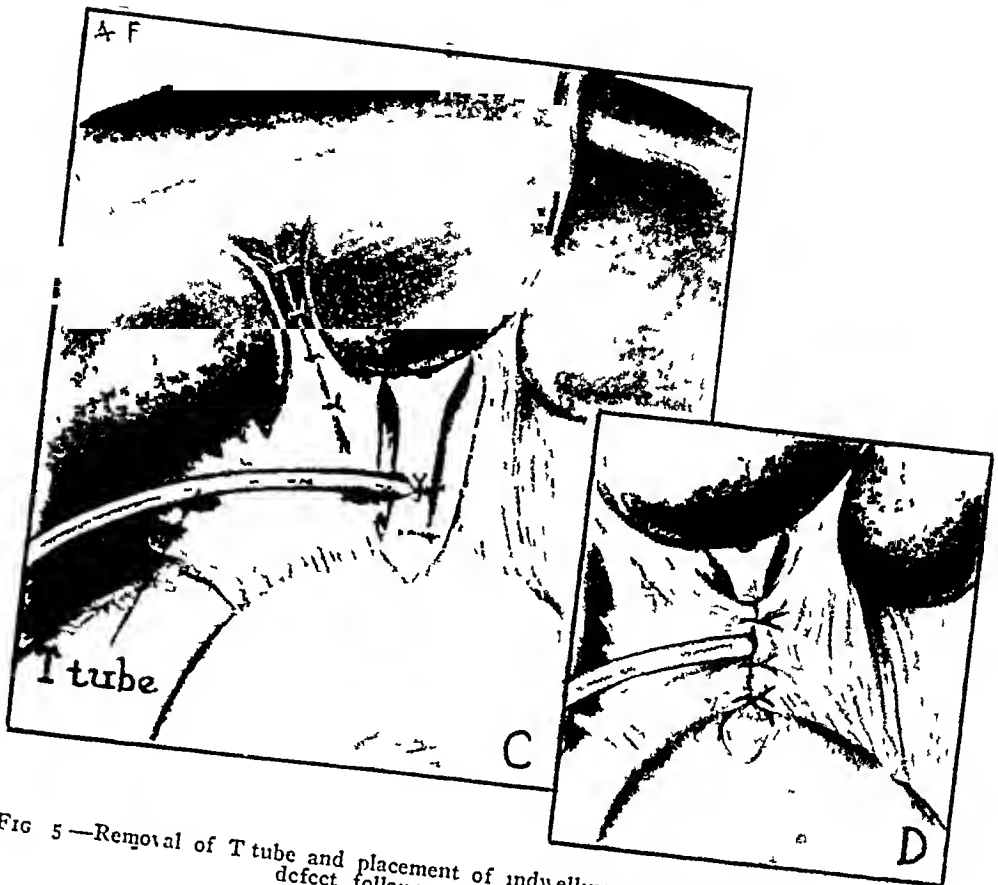


FIG 5—Removal of T tube and placement of indwelling soft rubber tube to repair the defect following removal of T tube

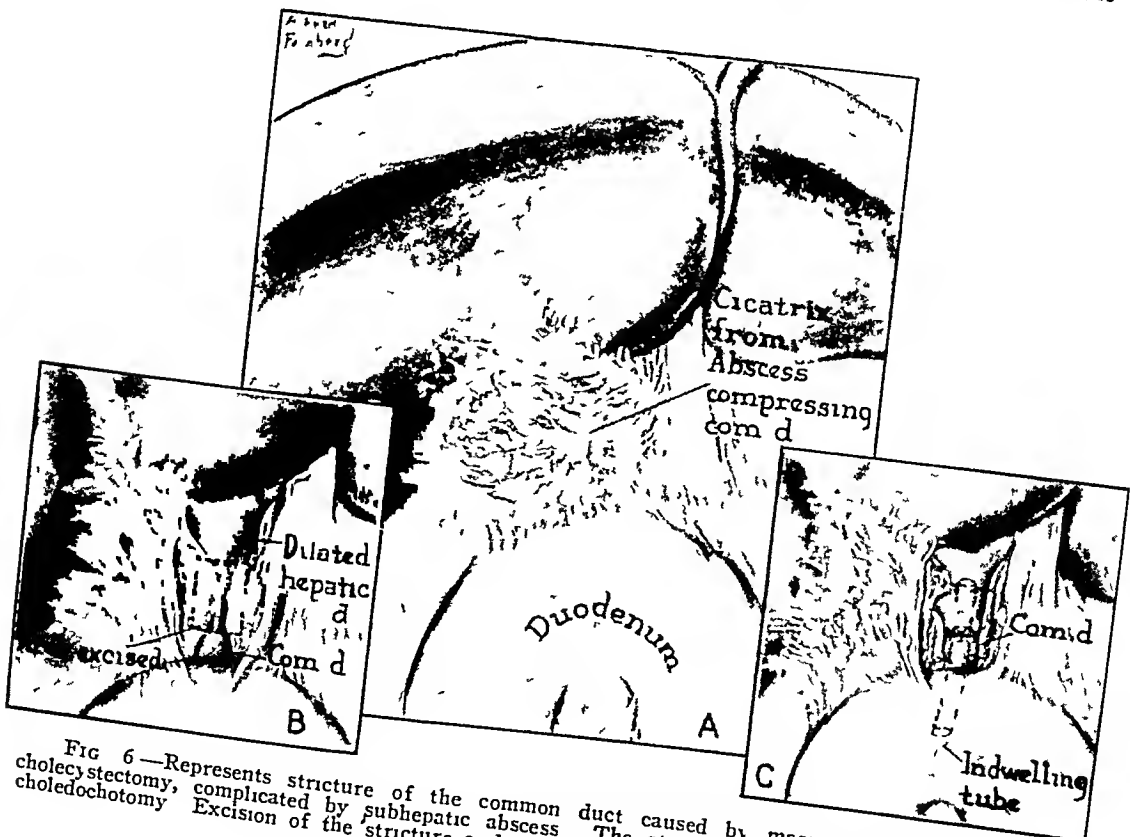


FIG 6—Represents stricture of the common duct caused by massive adhesions following cholecystectomy, complicated by subhepatic abscess. The strictured area was at the site of the choledochotomy. Excision of the stricture and reconstruction over indwelling rubber tube

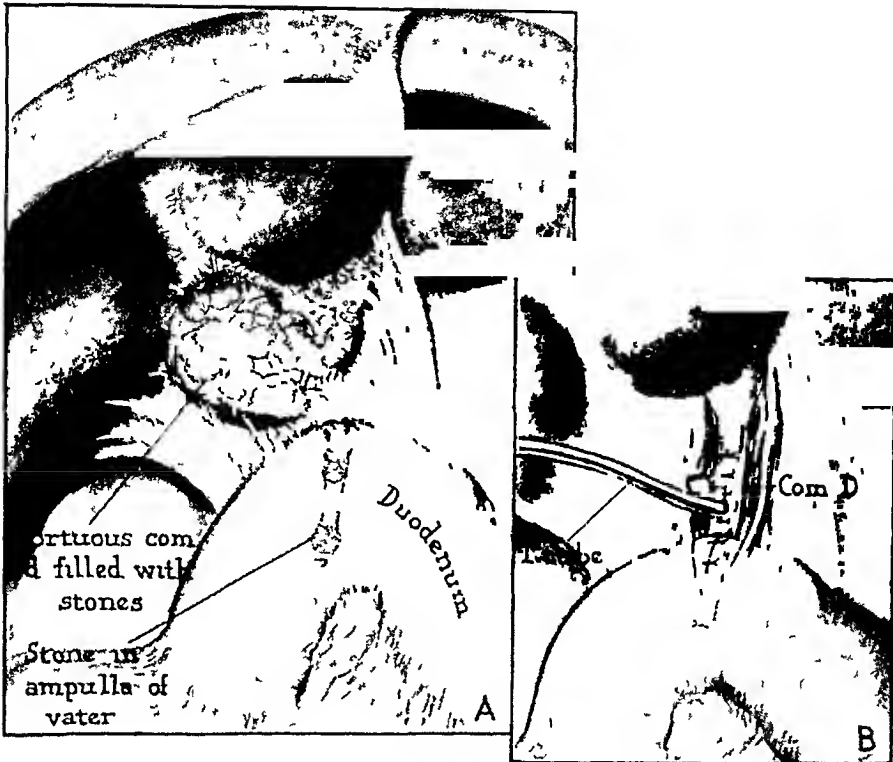


FIG 7—Represents the redundant common duct filled with stones. Stones also in the intraduodenal portion of the duct. Cholecystectomy 29 years previously. Redundant section of the common duct excised and the duct reconstructed over T tube.

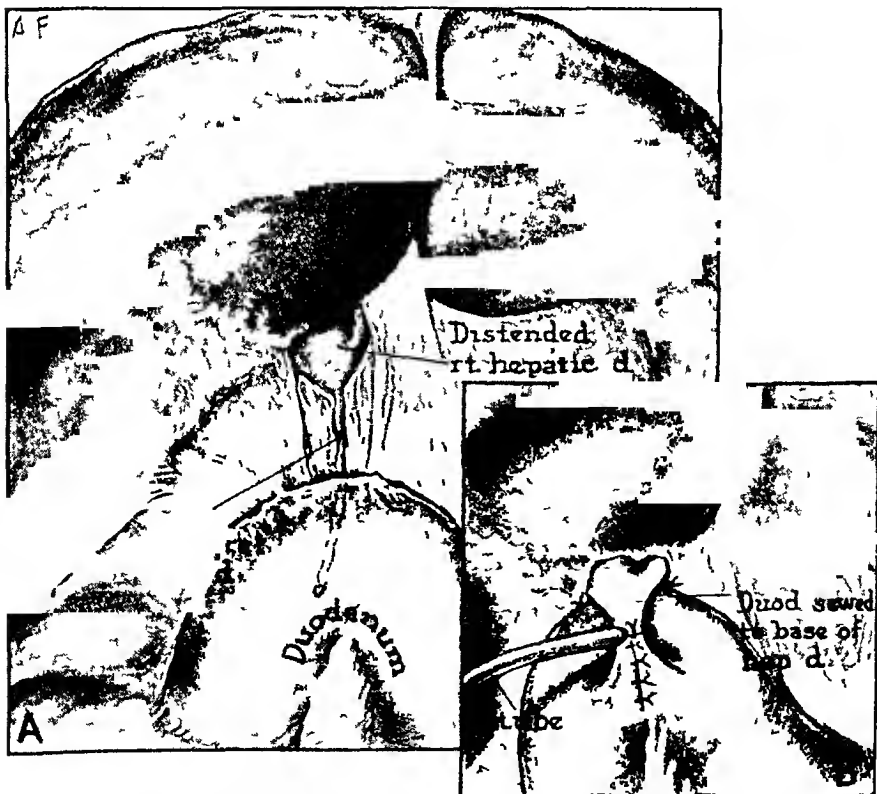


FIG 8—Reconstruction of the common duct following removal of T tube (Fig 7). Reconstruction of the common duct over indwelling rubber tube.

29 years before our examination in February, 1942. At this time she was jaundiced and suffered recurrent attacks of colic, chills and fever, with weight loss. Operation February 23, 1942, revealed a loop of small intestine adherent to the scar of previous operation in such manner as to form an aperture through which another loop of small intestine was adherent, producing a recurring intestinal obstruction. When the condition was corrected, there was revealed a mass located in the liver sulcus which at first resembled a contracted gallbladder, but when mobilized was found to be an enlarged and redundant common bile duct packed with calculi. Stones were found at the ampulla of Vater and in the intraduodenal portion of the common duct and in both left and right hepatic ducts. The redundant portion of the duct was excised and the calculi removed, thus necessitating dividing the intraduodenal segment of the duct. T-tube drainage was instituted for three months and then an indwelling tube of rubber was placed in the duct. The result was satisfactory, the jaundice disappeared, she gained in weight, and was symptom free. A small duodenal fistula persists with frequent passage of small concretions, but the patient, who is now age 70, is content.

The next case is that of a woman, age 34, who was seen in September, 1939, because of chronic duodenal ulcer and associated pyloric stenosis. During the mobilization of

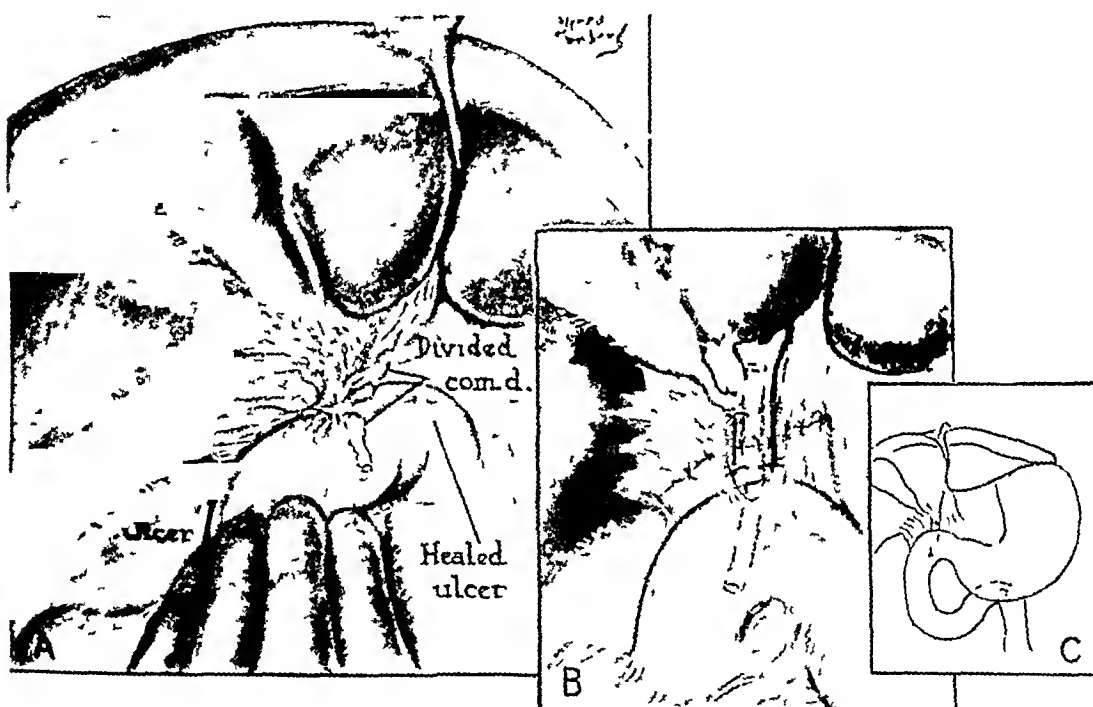


FIG 9—Necrotic destruction of the common duct caused by penetrating duodenal ulcer. Reconstruction of the duct over indwelling tube and posterior gastroenterostomy. Residence of tube three years. Secondary removal of tube necessary because of impossibility of tube to pass along the proximal loop of jejunum.

the duodenum in preparation for gastrectomy, a gush of clear bile flooded the operative field. It was recognized that the duct was involved in the ulceration, which had caused necrosis of the duct wall. The duct ends were evened up, an indwelling rubber tube was placed in the duct, followed by end-to-end anastomosis of the duct ends. The tube was anchored by interrupted silk sutures. A posterior no-loop gastro-enterostomy was performed after cauterization of the duodenal ulcer. Recovery was uneventful. The tube remained in good position for three and a half years, when it loosened and caused symptoms of colic. It was easily removed by transduodenal delivery. At this time it was observed that the common bile duct was in excellent condition. Retention of the tube during the interval offered less irritation than a metal tube might have caused.

These cases are taken from a personal series of 22 cases of acquired stricture of the common duct in which there was but one fatality. The variety in this series supports the formula of great variability in the pathologic and anatomic conditions encountered, and hence the variety of operations necessary for repair of these diseased common ducts.

DR CHARLES GORDON HEYD, New York City I think Doctor Sanders has reported a cross-section of the experience of most clinics in this country. In the series of our own which he so kindly mentioned, representing a 17-year period, one can see very definite trends in the type of surgery and indications for exploration. The group was made up of 54 surgeons. Quite obviously only the more demonstrable lesions were operated upon in the beginning. I should say we explore the common duct in about 14 per cent at the present time. There is an infrequent common duct condition that we have noted. A patient who has a degree or so of fever in the afternoon, has had a cholecystectomy some years ago, has an icteric index of 18 or 19, and on exploration is found to have a contracted duct. Drainage will reveal flocculent material, with sand, and drainage for a month or six weeks will bring about a cure.

The philosophy behind Doctor Sanders' paper is all-important. Biliary duct disease is a chronic disease and, without surgery, will end in chronic invalidism. We are apt to forget there are systemic manifestations of gallbladder disease long after the local symptoms have ceased to be the dominant factor in the patient's condition. Modern medicine has given us so many aids to ease a patient's disability that we are apt to make him comfortable at the expense of his future health and well-being.

DR FRANK H LAHEY, Boston, Mass. This is a subject in which we have been interested for a number of years, and it is an important subject because there is no doubt that family physicians frequently have been unhappy about the end-results of cholecystectomy for gallstones, and very properly so. This largely has been due to leaving stones in the common or hepatic duct.

We have established certain reasons for opening the common duct, dilatation of the common duct, contraction of the gallbladder, jaundice, suspected stone, induration of the head of the pancreas, and long-standing gallbladder infection with stones.

I would rather depend on the condition of the gallbladder than almost any other reason for opening the common duct. In other words, I open and explore the common and hepatic ducts when the gallbladder shows evidence of thickening or long-standing infection. At the Lahey Clinic we now open the common duct in 44 per cent of cases, which has resulted in the discovery of stones in 18 per cent. Our figures show that in 39 per cent of cases in which stones were found, no jaundice had occurred. For that reason, we have no confidence in limiting exploration of the ducts to those patients who are jaundiced.

Bile which is discolored and flocculent as it is withdrawn from the ducts is an indication for opening the ducts, however, stones sometimes exist in the presence of clear, yellow bile. Occasionally stones are present when the duct is not dilated. Therefore, one cannot set up clear-cut indications for opening the common and hepatic duct.

Too many common ducts are cut during cholecystectomy. We have operated upon 104 strictures of the common or hepatic duct, without ever having produced such a condition ourselves. Prevention of this accident involves a very simple principle. A gallbladder operation should not be undertaken without adequate anatomic exposure. There is no really completely satisfactory end-result after the common duct has been cut and there is a stricture. There are certain things that can be done, such as inserting indwelling tubes, vitalum or rubber. I recently published a report on one that had been in a hepatic duct for six years without symptoms. I do not like to put in a vitalum tube when a large section of the hepatic or common duct has been removed and the vitalum tube with its flange must rest directly upon the portal vein. I have sutured the portal vein too many times not to have a healthy respect for it. True, the portal vein has a low pressure, but it produces a high pressure in me when I cut it. When a large section of the common and hepatic ducts must be taken out, I would rather use a rubber tube. If I have to replace it in six or seven years, I can then insert a vitalum tube, lessening, thus, the possibility of penetration of the portal vein, as by that time the tube is surrounded by a good deal of scar tissue.

In the cases in which there is a large defect of the hepatic duct and no scar tissue remains in the bed left by the removal of the hepatic duct, it is an advantage to employ a T-tube since immediate decompression of the liver can be obtained. In these cases it is possible at the end of a year, when a good bed of scar tissue has surrounded the T-tube, to replace it with a straight rubber or vitalum tube and thus eliminate external biliary drainage.

As I have frequently said, I think the best treatment of stricture of the common or hepatic duct is better anesthesia, preferably spinal, plus better relaxation and exposure, with an accurate anatomic dissection about the junction of the common and hepatic ducts and the cystic artery. These precautions eliminate many postoperative problems.

DR ROBERT L. PAYNE, Norfolk, Va. The question of when to drain the common bile duct has been definitely laid down by Doctor Sanders and Doctor Lahey, but there has been no indication or rule laid down as to when a tube draining the common duct should be removed. Doctor Sanders merely passed this problem over by saying he removed the T-tube at variable periods of time. I wish to say that if we are going to lay down definite rules covering the institution of drainage of the biliary tree, then it would seem most reasonable that we should have some definite rules laid down concerning the cessation of tube drainage of the bile duct. In other words, we have been told over and over again when to put a tube in the common duct, but never when to take it out.

There are three factors to be considered in removing a common duct drain: (1) The liver factor—function normal or depressed, (2) the duct factor—inflammatory cholangitis, and (3) the sphincter factor—sphincter spastic, inflamed or obstructed. Whenever the common duct is obstructed by inflammation, stricture, stone or new growth, there is an increase of the intraductal pressure, and when this exceeds the hepatic secretory pressure, liver dysfunction, as evidenced by incompetence, and often degenerative changes in the liver result. A common bile duct drain is so placed for the purpose of decompressing the liver and draining the inflamed ducts until a normal state is attained. It should further be maintained until obstruction at the sphincter of Oddi is completely overcome. The criteria for removing a common duct drain are based on (1) chemical study of bile, (2) microscopic study of bile, and (3) the determination of the patulence of the sphincter of Oddi.

In the presence of liver damage and cholangitis, hepatic bile obtained through the T-tube shows a decrease or absence of bile salts, a decreased calcium level, and an increase of chloride level. To simplify this chemical study for practical purposes, I use only the determination of bile salts and the bile chlorides. The chloride level of normal bile is the same as blood serum level, therefore, the chloride level must approach the normal 450 to 550 mg per 100 cc and the bile salts in normal quantity be shown before the chemical factor related to drainage is considered normal. Microscopically, the bile should be studied for crystals of calcium bilirubinate, mucus and pus. When these clear up, the microscopic evidence for draining the common duct is removed. The sphincter of Oddi must be open so that bile drains freely into the duodenum before the T-tube can be removed. The best methods of determining the patulence of the sphincter of Oddi is clamping the T-tube off for 12 to 24 hours and studying the blood for any increased serum bilirubin level and, in addition, retrograde injection of an opaque substance, like hippuran, through the T-tube followed by roentgenographic visualization. I do not remove a T-tube until all three of these studies come together, namely, a normal liver factor, duct factor and sphincter factor, by which I feel that we have a more intelligent interpretation of when to take out the T-tube than simply to remove it empirically a certain number of days after its introduction into the common duct.

I realize that these methods described are distinctly crude and will permit of considerable improvement. I would urge that more investigation and study of this problem be made by all surgeons who are doing bile tract surgery, feeling that some day a more intelligent interpretation than I have presented will be offered as definite indications for discontinuing the drainage of the biliary tract.

DR JAMES D. RIVES, New Orleans, La. I would like to comment on two features of this discussion that seem to me pertinent. It is evident that in the country from which Doctor Lahey draws his cases the surgeons are less timid than they are in and around New Orleans. Here, we not infrequently see cases in which the surgeon has done an incomplete removal of the gallbladder or has left a very long cystic duct stump. Within the last year I have seen three such cases in which the remnant of gallbladder or duct caused recurrent attacks of jaundice in the absence of stones.

I would like to report a single case that seems to have bearing on Doctor Womack's suggestion that cholesterol may be deposited in the sentinel node. Several years ago I operated upon an elderly white male with complete obstruction of the common bile

duct and a long-standing history of chronic cholecystitis, with recurrent acute attacks. On exploration, I found a huge mass in the gastrohepatic omentum obscuring the common duct, the hepatic artery, and the portal vein. This was surrounded by very extensive sub-acute and chronic inflammatory reaction. I had at first thought that this was a huge stone that had been extruded from the common bile duct. By very cautious dissection, I was able to demonstrate that it lay entirely outside the duct and consisted of what appeared to be, and what on examination proved to be, a large mass of cholesterol, measuring about 2 x 3 x 4 centimeters. The common duct was then opened and several stones removed. No evidence of damage to the wall of the duct existed and I have concluded that this cholesterol deposit was probably in the lymphatic structures.

DR WARREN COIL, Chicago, Ill. I was much interested in Doctor Womack's statement that disease of the gallbladder is due to chemical factors and not primarily to bacteria, *i.e.*, the bacteria get in secondarily. We have arrived at the same conclusion experimentally. In a series of dogs we obstructed the cystic duct partially and observed the gallbladder for several months. For three months nothing happened to the gallbladder wall, however, after six months the wall becomes thickened. Microscopically, we found the same condition we see in the surgical pathology room, namely, thickening of the wall, fibrosis, *etc.* I believe Doctor Womack's explanation of cellular reaction to cholesterol and bile salts sounds very feasible. We all know that cholesterosis has not shown evidence of being the cause of many symptoms. Nevertheless, his suggestion that cholesterosis and deposit of bile may be an early stage in the pathogenesis of gallbladder disease appears as definite evidence that pathologic changes may develop.

DR BARNEY BROOKS, Nashville, Tenn. The remarks which have been made concerning the most appropriate time to remove a T-tube from the common bile duct prompt me to suggest that in my opinion it is best not to use a tube at all. We have not placed any sort of a tube in the common bile duct for a period of at least 15 years. I believe the only indication for the use of a T-tube is in instances in which this is the *only method of establishing continuity* between the hepatic duct and the intestinal tract. In other words, we use a T-tube only when there is not a common duct in which to place it. In instances in which a stone is removed from the common duct, the opening in the duct is carefully closed. A cigarette drain and small rubber tube are placed down to the site of closure, and in at least half the cases the patient recovers without any biliary fistula.

DR R. L. SANDERS, Memphis, Tenn. (closing). Referring to Doctor Brooks' statement, a good many surgeons do not use drains in the common duct, but close the duct primarily after taking out the stones. I shall not argue this point, as I believe that whether one should or should not drain the duct is a matter of individual opinion and end-results.

As to anesthesia, we have used a general anesthetic, with a supplementary field block if necessary, in practically all our cases and have found relaxation excellent and exposure of the gallbladder and ducts ample. Fortunately, we have never injured nor accidentally cut the duct, so far as we know, nor have we encountered anything like the number of damaged ducts observed by Doctor Lahey. Certainly, we have no reason to alter our practice in regard to anesthesia, although we realize that the choice in this matter, also, is largely one of individual preference.

In common with many other members of this Association for a number of years I have been teaching medical students in preparation for private practice. It is my opinion that we should be cautious in advising these inexperienced young men to open the ducts unless the indications are definitely present. Surgeons in larger medical centers, who have had many years of experience, might perform a choledochotomy in every other case without serious risk to the lives of their patients. The procedure is not without danger, however, and for the average surgeon, especially the one recently out of training, I consider such a practice contrary to good, sound surgical principles. From an experience including approximately 2,000 gallbladder operations over a period of more than 30 years, I am inclined to agree with Doctor Heyd that definite indications for opening the ducts are encountered in only 15 to 25 per cent of cases. Our end-results have proved the truth of this point.

SYMPOSIUM ON VASCULAR SURGERY

COMBINED VASCULAR AND NERVE INJURIES OF WARFARE*

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AND

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FROM THE VASCULAR AND NEUROLOGICAL CENTERS, ASHFORD GENERAL HOSPITAL WEST VIRGINIA

IT WOULD APPEAR that in this war the incidence of vascular injuries and of concomitant nerve injuries would probably surpass that of any other war. In addition to ordinary wounds produced by machine gun, rifle bullets and shrapnel, a great many multiple injuries are being produced by fragmentation of land mines, grenades and aerial bombs, as will be shown in a review of individual cases. Land mines and grenades may produce as many as fifty small individual wounds scattered over the body without causing death. This naturally increases the chance of vascular and nerve injuries. Of more significance to the study of major wounds to blood vessels and nerves is the fact that improved methods for the control of shock and infection have preserved a greater number of such injuries for subsequent observation.

Nerve lesions leading to motor and sensory paralysis of the upper and lower extremities are so obvious, because of their disabling consequences, that vascular injuries, at least in their early stages, are frequently overlooked. Conversely, vascular injuries in which a large pulsating hematoma is present may mask injuries to neural structures. With this in mind, it is of extreme importance that patients having nerve lesions be examined with great care lest an aneurysm or an arteriovenous fistula, or other blood vessel injury be missed. Only by a careful palpation, inspection, and auscultation of every wound can this be accomplished.

It is well to recall that all large blood vessels, with a few exceptions, are accompanied by peripheral nervous tissue. This is to be remembered especially in wounds of the neck where the great vessels lie in such close proximity to important cranial and cervical nerves. The same is likewise true in the brachial, femoral and popliteal regions, and while aneurysms of a traumatic nature are more frequently found at those points, it is nevertheless true that any vessel, regardless of its size or location, may be the seat of a disabling vascular injury.

It is not the purpose of this paper to review the common signs and symptoms of aneurysms, or of the ordinary manifestations of nerve injury or nerve section. Reports in the past which have dealt with aneurysms,

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La

have in the main neglected, or have failed to note concomitant nerve lesions. For this reason cases are presented here to show the frequent combination of such injuries.

In the inception of any vascular injury such as an aneurysm or fistula, external or internal bleeding may be severe and the immediate care, quite correctly, is directed to the control of the hemorrhage. In many instances, therefore, the appraisal of damage to neural tissue is delayed. The appearance of the external wound seen days or weeks after the original trauma is of little value in determining the state of the blood vessel or nerve injury. In many injuries hemorrhage may be slight, even though a major vessel is involved. In the absence of severe laceration, bleeding may be controlled by the pressure of the soft tissues and thus pulsating hematoma or false aneurysm will be formed.

The history will usually suggest the extent of the nervous tissue damage because even during the acute stage of the injury the patient, if conscious, is usually immediately cognizant of sensory and motor loss, whereas, the presence of an aneurysm or a fistula may be discovered only at a much later date. For instance, paralysis of a peripheral nerve recognized by the patient at the time of the wound might indicate severe trauma or even section of that nerve, whereas, if it came on at a later date in the presence of an aneurysm, it most certainly would be due to pressure, a fact of considerable prognostic importance.

In the presence of a large number of casualties and under battle conditions such as front line hospitals are now working, a diagnosis, though incomplete, or even incorrect, may be carried by a wounded soldier for some time. This does not imply that proper treatment has not been given but it does entail upon those who are working in the Zone of the Interior or in general hospitals distant to the battlefield, the necessity of particularly careful examination, uninfluenced by any previous diagnosis. Moreover, it is a well known fact that a vascular lesion may develop slowly to the point of recognition. For example an arteriovenous fistula, surely present from the onset of injury, may not show the characteristic signs until some time later when edema and tissue hemorrhage have been absorbed. This is substantiated by the fact that vascular lesions were discovered in five patients in this general hospital upon whom only neurologic diagnoses had been made previously.

The neurologic sequelae of gunshot wounds of the central and peripheral nervous systems have varied but little in the previous armed conflicts in which these disturbances have been studied. The causalgia that Weir Mitchell described so graphically in the American Civil War differs in no respect from that observed today in Army General Hospitals. In this war the character of the inflicting forces has altered both the type and particularly the frequency of injuries to neural tissue as exemplified in the first instance by blast injuries and in the second by aerial bomb and antipersonnel land mine injuries.

I—VESSEL-NERVE INJURIES OF THE NECK

Among these previously well recognized neurologic syndromes are those extracranial lesions of the last four cranial nerves caused by gunshot wounds. As Pollock and Davis¹ have stated, the number of such syndromes is limited only by the possible combinations of complete or incomplete paralyses of these several cranial nerves and the descriptive ability of the various observers. Among the classical syndromes involving all or several of the last four cranial nerves are those of Avellis,² consisting of a unilateral paralysis of the soft palate and the larynx, from a lesion of the vagus and the internal branch of the spinal accessory nerve, of Schmidt,³ characterized by the inclusion of the external branch of the spinal accessory nerve to the foregoing symptoms, and of Jackson,⁴ which includes, in addition to all these symptoms, involvement of the hypoglossal nerve.

During the course of and following World War I, Vernet,⁵ Collet,⁶ Sicard,⁷ Villaret,⁸ Barbé,⁹ Korner,¹⁰ and Pollock¹¹ added significant contributions to the literature of War injuries involving these neural structures.

These authors gave to the combination of cranial nerves involved descriptive terms denoting either the neurologic distribution of or the anatomic location of the causative wound, such as, "syndrome of the posterior lacerated foramen" (Vernet), "glosso-laryngo-scapulo-pharyngeal hemiplegia" (Collet), "complete syndrome of the last four cranial nerves" (Sicard), and "syndrome of the posterior retroparotid space" (Villaret).

Whatever the syndromes may be termed, the resulting neurologic dysfunction depends upon the close anatomic continuity of the last four cranial nerves in the early part of their extracranial courses. In the jugular foramen, the glossopharyngeal, vagus and spinal accessory nerves, in order from before backward, lie between the inferior petrosal sinus anteriorly and the internal jugular vein posteriorly. At its exit from the jugular foramen, the internal jugular vein lies to the outside of the nerves and the carotid artery, with its accompanying sympathetic plexus, is placed closely in front and medially to these nerves. The hypoglossal nerve is in close proximity since it leaves the skull through the adjacent anterior condyloid foramen. In their more peripheral courses, the four nerves remain in close approximation to a point slightly below the tip of the mastoid, in the so-called retroparotid space. More laterally placed, in the coronal plane of the head, lie the seventh and fifth nerves.

Although reports of injuries to the jugular vein and carotid artery in association with injuries to the last four cranial nerves are rare in the World War I literature, such a combination of nerve and vessel injury must have occurred with some frequency. Among these infrequent observations of similar cases is that noted by Heyrovsky¹² who described involvement of the last four cranial nerves with a spurious aneurysm of the vertebral artery. Aneurysmorrhaphy was successful, but as in Case 1 (*infra vide*) the neural defect showed no evidence of improvement. That they were not reported would indicate that these cranial nerves may be injured without concomitant

vascular injury, as noted by Vernet, or that such vascular injuries may occur and heal spontaneously, or that the vascular injury was so formidable that, lacking modern methods of shock control, these cases did not survive. It is obvious that grave vascular injuries of a chronic, progressive nature do occur with the various classical syndromes indicating involvement of the last four cranial nerves, and that, furthermore, the control of such vascular injuries is of paramount importance in the rehabilitation of the wounded soldier.

Case 1—*C J H, Hosp No 991 Gunshot wound of face Removal of 44 caliber bullet in left occipitomastoid region Involvement of V, VII, X, XI and XII cranial nerves and production of A-V aneurysm No improvement in neurologic status after resection of vascular lesion*

On November 10, 1942, this soldier was struck in the left malar region at close range with a French 44 caliber revolver bullet. The missile traversed the face, the lateral aspect of the neck, and became imbedded in the soft tissues of the left occipitomastoid region. He staggered back under the impact of the bullet but did not lose consciousness. He noticed at once loss of feeling in the mouth and lower left side of the face. His voice was hoarse, and he was unable to fully lift the left arm from his side. There was no extensive external hemorrhage, but the tissues of the side of the neck swelled considerably. Within a few days he became cognizant of a loud buzzing in his left ear. Upon occasion, his pulse rate would become very rapid. On December 22, 1942, the bullet was removed from the left occipital region, and on February 22, 1943, the left common carotid artery was ligated, without change in his symptoms.

On admission to the Ashford General Hospital, two months later, there was a small scar over the left malar region, denoting the wound of entry. There was a short operative scar 4 cm mesial to the tip of the left mastoid. The tissues in this region appeared full in comparison to those on the right. Palpation revealed a deeply situated pulsating mass with a distinct systolic thrill. Auscultation noted a continuous bruit accentuated in systole with maximal intensity over the occiput which could be obliterated by deep pressure over the sternomastoid muscle. Arterial pulsation was absent over the left common carotid artery, the site of the earlier ligation. It was thought that this was an arteriovenous fistula of the cirroid type, probably involving the occipital artery and vein deep to the muscles and posterior to the mastoid process. The question of involvement of the vertebral artery with accompanying veins in this region was considered.

Neurologic examination disclosed the following findings of significance. The pupils were of equal size, and there was no enophthalmus. There was analgesia and anesthesia over the third branch of the left fifth nerve, there was loss of taste over the anterior two thirds of the left side of the tongue, the soft palate was pulled to the right upon phonation, and the gag reflex was absent on the left side, the voice was hoarse and laryngoscopy disclosed a left abduction palsy, the left arm could not be abducted above 90 degrees, and there was atrophy of the left sternomastoid and of the lower two-thirds of the trapezius muscles, the superior third of this structure was incompletely paralyzed. The left side of the tongue was atrophic and furrowed and protruded to the left (Fig 1).

The neurologic diagnosis was involvement of V, special visceral afferent (taste) of VII, IX, X, XI, and XII cranial nerves, similar to those syndromes reported by Collet, Vernet and Sicard, with the addition of the V and VII nerve lesions. To this was added the diagnosis of an arteriovenous aneurysm, probably of the occipital vessels.

An excision of these vessels was carried out on June 15, 1943. A semicircular

incision beginning over the left mastoid muscle was carried upwards over the base of the skull to the midline. The deep muscles were cut and retracted caudally. The external carotid artery was ligated, but this had but little if any effect upon the cirroid aneurysm, which could be seen and felt at the base of the skull. This aneurysm was excised by ligating and cutting numerous arteries and veins which were seen to communicate with vessels entering the skull. Considerable bleeding was encountered,

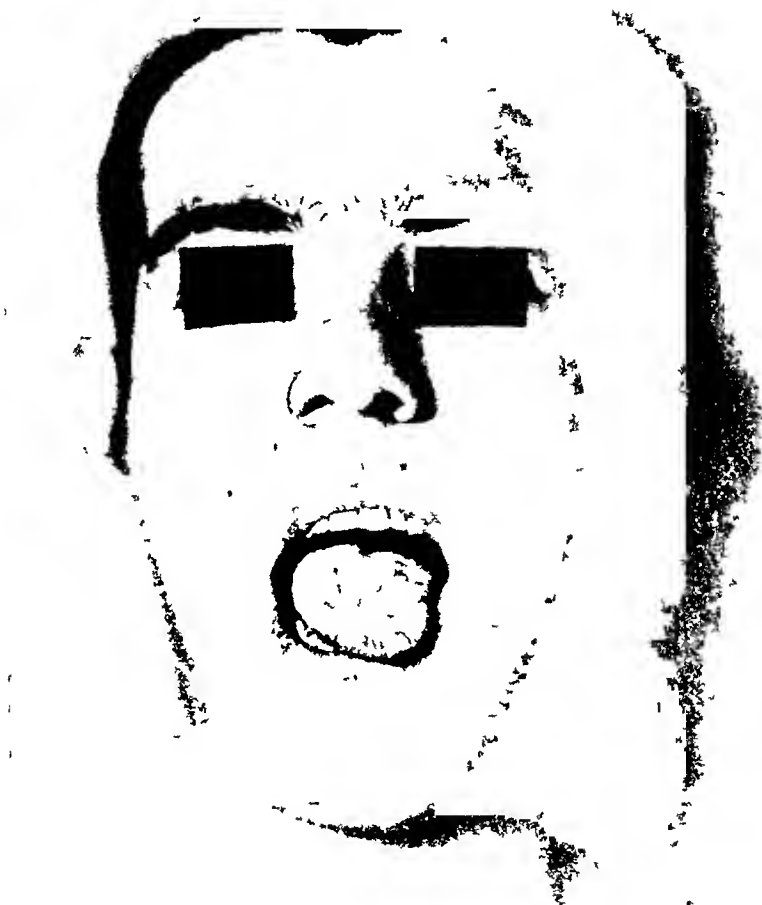


FIG 1—Case 1 Paralysis of left hypoglossal nerve

which was controlled by coagulation and by the use of fine silk ligatures. At the end of the operation the bruit and thrill had disappeared.

Two weeks later, as a result of a friendly wrestling match, the wound was opened and a severe secondary hemorrhage occurred. This was controlled by hemostats which were left in place, and by packing. Following this the vertebral artery was ligated, which apparently controlled the bleeding since no further hemorrhage occurred with the removal of the clamps and packing. The wound healed uneventfully. There was no return of the bruit and thrill. There was no change in the neurologic findings upon discharge three months later and upon review examination three months after discharge.

Case 2—*H C H, Hosp No 1397 Gunshot wound left side of neck, April 31, 1943 Involvement of cranial nerves VII, X, XI, XII, and second cervical with incomplete cicatricial occlusion of left common carotid artery Artery freed from cicatrix Progressive improvement in neurologic defect*

On March 31, 1943, this soldier was injured by aerial bomb fragments which struck the left side of his neck, left thigh, and left frontal region of the scalp. He was unconscious for two hours. Severe hemorrhage persisted from the neck wound, and two plasma transfusions were given during the first 24 hours after the injury. Forty-eight hours later the neck wound was explored, and foreign bodies were removed. At this time he was unable to talk, move the left side of his face, or shrug the left shoulder. He noted loss of feeling over the lower third of the left side of the face. He had some difficulty swallowing fluids. Three weeks after the injury, the aphonia cleared, and his voice became progressively less hoarse. Both facial and shoulder movements improved slowly but steadily. From that period in his convalescence until his admission to Ashford General Hospital on May 10, 1943, he noticed an intermittent singing noise in the left ear.

There was a small, stellate, puckered scar below and anterior to the tip of the left mastoid. Palpation over the scar and in the anterosuperior cervical triangle disclosed a small, tubular expansile mass. Auscultation over the mass revealed the presence of a harsh, continuous bruit, accentuated in systole, which could be obliterated by compression of the common carotid artery.

Neurologic findings included an apparent enophthalmus on the left, moderate weakness of the musculature about the left angle of the mouth, normal taste perception and hoarseness with an abduction paralysis of the left vocal cord. The superior third of the left trapezius muscle was atrophic with weakness of shoulder elevation, but with normal abduction of the left arm. The tongue was atrophic and protruded to the left. There was an area of hypalgesia and hypesthesia corresponding to the anterior fibers of the second cervical nerve.

The neurologic diagnosis was involvement of the VII, X, XI and XII cranial and the second cervical nerves. With the exception of the VII nerve disturbance this case was similar to the syndromes previously recorded. The more inferiorly and laterally placed site of injury in this instance explained the lack of involvement of the glossopharyngeal nerve. Surgical exploration of the expansile mass in the cervical region disclosed a cicatricial, incomplete occlusion of the common carotid artery with proximal dilatation of the vessel. The neurologic disturbance, with the exception of the abduction paralysis of the left vocal cord, improved steadily until discharge three months later.

The release of scar tissue about the carotid artery led to complete disappearance of the bruit and thrill, a finding worthy of note, since apparently scar tissue contracting about a vessel may produce the cardinal physical findings of an arteriovenous fistula.

Case 3—*R Z, Hosp No 3007 Gunshot wound, 20 mm shrapnel, left mastoid region on December 3, 1942 Involvement of cervical sympathetic, VII, IX, X, XI and XII cranial nerves, associated with A-V aneurysm of internal carotid artery and internal jugular vein and evidence of increased intracranial pressure Resection of A-V aneurysm Moderate improvement in neurologic status*

This soldier was injured on December 3, 1942, by pieces of shrapnel from a 20 mm shell which struck the left mastoid region and left shoulder. The former wound bled profusely for a few seconds, and then hemorrhage ceased spontaneously. Three days later the mastoid-cervical wound was explored and a foreign body removed. On the following day, he noted a buzzing sound in the left ear, the appearance of a swelling below the wound and for the first time, developed moderately severe generalized headache. There was weakness in the muscles of the lower half of the left side of the face, and his voice was hoarse. He noticed that choking would follow the ingestion of fluids, but that

solid food was tolerated without difficulty. When he became ambulatory, he realized that he could not abduct the left arm above 90 degrees. On April 3, 1943, the left common carotid artery and left internal jugular vein were ligated. On June 11, 1943, the A-V aneurysm involving these vessels was resected, both procedures being performed by Lt Colonel William V Cox, M C. The patient's convalescence from these operations was without untoward incident. Neurologic examination was carried out in the Ashford General Hospital on August 30, 1943.

The site of the operative procedure showed nothing abnormal, and there was no evidence of recurrence of the arteriovenous aneurysm. Vision in the O D was 20/20, in the O S vision was reduced to hand movements, with fingers recognized in the



FIG 2—Case 3. Arteriovenous aneurysm of internal carotid jugular vein. The vascular lesion and the narrowed palpebral fissure are apparent. (Case of Lt Colonel William V Cox.)

temporal quadrants. The optic nerve head of the right eye was normal. The left neuroretinal outline was clear, but the temporal half of the disk was pale. Adjacent to the temporal margin were two or three hyaline deposits and similar deposits were noted nearer the macula. An area just above the disk was pale. The changes in this fundus suggested an earlier papilledema with subsequent atrophy. Previous studies, prior to operation, had disclosed a bilateral papilledema of three diopters.

The pupils were equal and active to light stimulation and upon accommodation. There was intermittent conjunctival injection on the left. On July 9, 1943, Captain C N Eastman, M C, had reported a narrowing of the left palpebral fissure, enophthalmus, some decrease in intra-ocular tension as compared to the right and normal side, loss of the ciliospinal reflex and loss of sweating over the left side of the face. There was

no change in sensation over the domain of nerve V. There was a contracture of some muscle fibers at the angle of the mouth, causing inversion of this structure. There was weakness of the zygomaticus, triangularis and lower fibers of the orbicularis. There was slight loss of the normal palatal arch on the left and the soft palate pulled to the right upon phonation. The voice was hoarse and laryngoscopy revealed an abduction paralysis of the left vocal cord. The left sternomastoid muscle was functionless, and the left arm could not be abducted above 90 degrees.



FIG 3—Case 4 Exophthalmos. Left seventh nerve paresis. Note wound of entry on lateral aspect of nose.

The neurologic diagnosis was incomplete involvement of the cervical sympathetic chain, and cranial nerves VII, IX, X, XI and XII, the syndrome described by Villaret. All components of the neurologic picture had improved considerably except those involving cranial nerves X and XI. Among six gunshot wounds of the last four cranial nerves described by Vernet with Lanvois and Patel is one quite identical with this case, but concerning which no postoperative course is available.

From the overseas clinical record it is clear that this patient had bilateral papilledema of three diopters before operation. This would suggest an increase in pressure in the venous circulation of the brain. Such a course is not incompatible with what is known

VASCULAR AND NERVE WAR INJURIES

of the physiology of an arteriovenous fistula, where arterial blood at an increased pressure enters the venous system (Fig 2)

Case 4—*J D M, Hosp No 1345* Gunshot wound of face and neck Involve-
ment of V, VII, and XIth cranial nerves with development of arteriovenous aneurysm
of cavernous sinus and internal carotid artery Ligation of common carotid artery
On December 12, 1942, this officer was struck by a 30 caliber bullet The missile
entered 1 cm mesial to the inner canthus of the left eye, and made its exit beneath the
left mastoid region He became unconscious at once and remained so for 24 hours
He was confused and drowsy for the following four days Debridement was carried
out on the evening of the injury, and sequestrectomy of a portion of the condyloid
process of the mandible was done ten days later He early appreciated numbness along

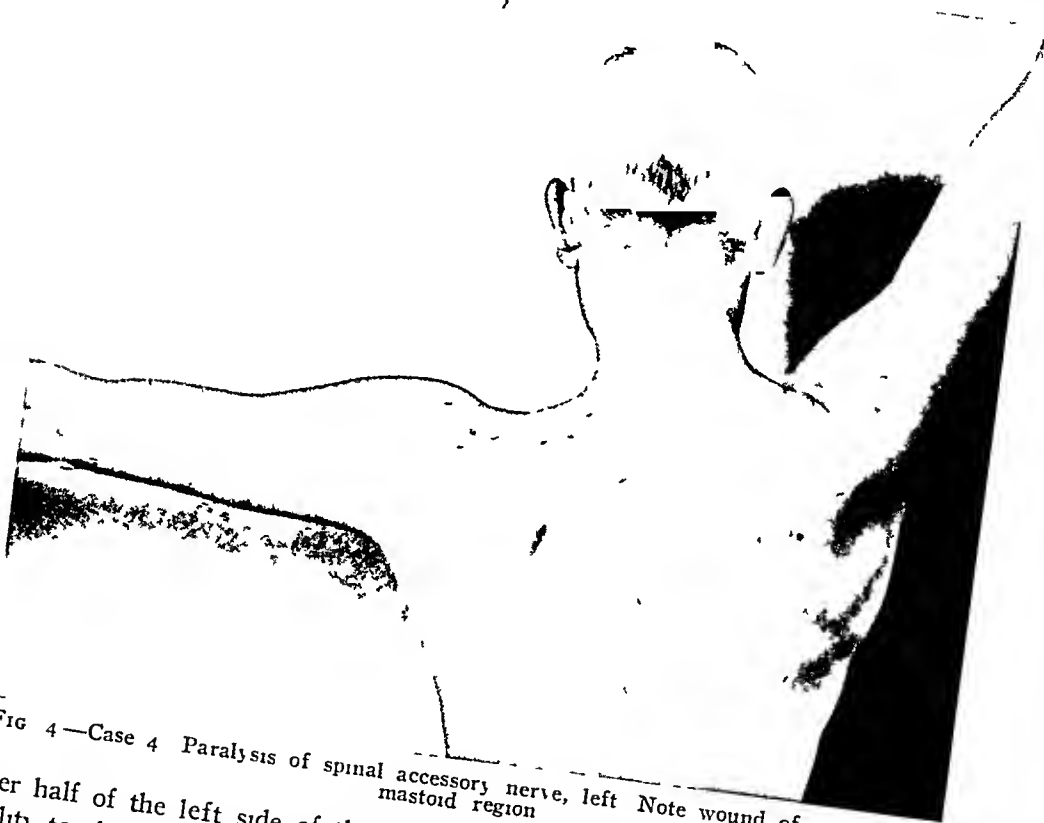


Fig 4—Case 4 Paralysis of spinal accessory nerve, left Note wound of exit beneath mastoid region

the lower half of the left side of the face, weakness of the left facial musculature and an inability to abduct the left arm above 90 degrees From the time of adequate orientation, he had noted a protrusion of the left eyeball which had never diminished in size Occasionally he reported hearing a "roaring sound like the ocean" in his left ear
The striking feature upon first examining this officer was the moderate proptosis of the left eyeball There was conjunctival edema and vascular congestion There was a small, round scar on the lateral aspect of the nose 1 cm from the inner canthus of the left eye Below the tip of the left mastoid was a 2 x 4 cm scar which was adherent to the deep structures of the neck

Neurologic examination disclosed normal direct and peripheral vision The left neuroretinal outline showed minimal blurring along its nasal margin The retinal arterioles pulsated, and the veins were full There was hypalgesia and anesthesia over the third branch of nerve V There was almost complete paralysis of the sternomastoid musculature on the left side There was pronounced atrophy of the winging of the muscle on the left The trapezius muscle was atrophic with marked winging of the vertebral border of the scapula and loss of abduction of the left arm above 90 degrees (Figs 3 and 4)

The supra-orbital veins were engorged, and a distinct, continuous thrill could be felt in both the upper and lower left eyelids. This thrill was transmitted into the neck over the carotid vessels. Over the left eye, forehead and left side of the neck there was a harsh, continuous roaring bruit, accentuated in systole. The left eyeball pulsated slightly. The whole picture was one of pulsating exophthalmos and was thought to be due to a communication between the cavernous sinus and the left internal carotid artery. On May 26, 1943, the left common carotid artery was partially compressed with an aluminum band, and it was felt that about 80 per cent of the blood flow through this vessel was stopped. Following this there was definite improvement in the exophthalmos, and, on June 23, 1943, the carotid artery was again exposed, together with its terminal branches. At this time temporary occlusion of the common, internal, and external carotid vessels did not obliterate the bruit previously described, and it was felt, therefore, that a large blood supply to the fistula was coming from the other side and from the vertebral vessels. At this time the common carotid artery was doubly ligated with braided silk and the wound closed. Following this there was additional improvement in the exophthalmos, although the bruit and thrill were only slightly affected.

The patient was seen in consultation by Dr. Rudolph Matas, and he agreed in the opinion that no further operative procedure should be carried out at this time.

The neurologic diagnosis was involvement of the V, VII and XIth cranial nerves associated with an arteriovenous aneurysm of the left internal carotid artery and cavernous sinus (Figs. 3 and 4).

DISCUSSION

Any specific syndrome of the cranial nerves in their extracranial courses depends upon the unpredictable vagaries incident to trauma through gunshot wounds and upon the time interval at which the neurologic observations are made. Although it is obvious that their close anatomic grouping sets the stage for multiple involvement of the last four cranial nerves, yet their separation into syndromes is of dubious neurologic import. From a study of these cases, and from other traversing wounds of the face and neck without significant change at the time of neurologic study, several observations of prognostic import seem worthy of comment. In the first place, injuries of nerves V and VII of transient or of rare permanent nature, may be engrafted upon the usual classical syndromes of the last four cranial nerves. This superimposed neurologic defect has exhibited a strong tendency toward spontaneous regression in the patients under observation. In the second place, a lesion of the last four cranial nerves, whether acute or of a chronic and perhaps regressive character, may incapacitate the patient in only two significant respects. In Case 3, there was pronounced difficulty in the early days after the injury, in swallowing fluids. Six months after the injury, the persistent abduction paralysis of the left vocal cord precipitated respiratory collapse at the beginning of induction of anesthesia, preliminary to the introduction of an intratracheal tube. A similar episode occurred in this hospital under identical circumstances in the treatment of Case 2. The involvement of the external branch of the spinal accessory nerve has shown little tendency toward improvement and the loss of abduction of the upper extremity above 90 degrees remains as a defect of considerable magnitude. Direct exploration of the region of the jugular foramen with the view of decreasing this neurologic disturbance has not been carried out or contemplated in these cases.

Finally, the experience that vascular injuries are associated with many injuries of the last four cranial nerves may not represent the true frequency of the combined injury, since this hospital has been designated as a Vascular Center. The combined injury, whether immediately fatal from hemorrhage or amenable to treatment, must be fairly common because of the anatomic contiguity of the vascular and neural structures.

The vascular lesion may include, in individual cases of a chronic nature, cicatricial occlusion, A-V aneurysm, false aneurysm or even similar lesions from indirect violence similar to Case 4. The fact that the vascular lesion in Case 2 was unrecognized previously is worthy of comment. The vascular injury may bear no relationship to the extent or duration of the neural damage except that of a concomitant injury. In these patients at least, the neural disturbances developed immediately following injury and were not favorably influenced by repair of the vascular lesion. That the aneurysmal mass may influence adversely the extent of neural injury in some instances is not disputed.

II—VESSEL-NERVE INJURIES OF THE UPPER EXTREMITY

It is the consensus of opinion of former writers on this subject that neural complications are much more common in aneurysms of the upper extremity than in those of the lower extremity. Thus Fromme,¹³ in a long, carefully documented article, recorded 13 aneurysms of the upper extremity with neural changes out of a total number of 16. Makins¹⁴ stated that 25 per cent of the subclavian aneurysms showed involvement of the brachial plexus and out of 54 cases involving the axillary and brachial arteries, 43 per cent showed involvement of neural structures. In Maurer's¹⁵ series of 71 aneurysms of the upper extremity, approximately 25 per cent showed neural complications. On the other hand, in Makins' extensive series of 170 femoral artery injuries and 85 popliteal artery injuries, concomitant nerve injury was reported as rare. Illustrative of the combined vessel-nerve injuries to the first part of the axillary artery is that described in the following case.

Case 5—D F H, Hosp No 2869. Traversing gunshot wound of left infraclavicular space on March 28, 1943, followed by paralysis of left arm for two months. Subsequent resection of false aneurysm of first part of left axillary artery with slow improvement in neurologic status.

On March 28, 1943, this soldier was struck by a rifle bullet in the left infraclavicular space which traversed the apex of the axilla and made its exit lateral to the tip of the left scapula. External bleeding was minimal at the time of injury and a massive subcutaneous hematoma did not develop. The left arm became paralyzed at the moment of injury and did not exhibit evidence of improvement for two months. Return of function was marked first by flexion of the forearm, and then by extension of the wrist. Sensory loss was noted over the entire arm after injury, but regressed slowly until it involved the outer aspect of the forearm, the thumb, and first three fingers. After hospitalization in the Zone of the Interior, an aneurysm of the first part of the axillary artery was disclosed, and he was referred to the Ashford General Hospital for treatment.

Examination noted a small, well healed wound of entry 4 cm below the outer third of the left clavicle and a larger, irregular scar denoting the wound of exit lateral

to the tip of the left scapula. In the left infraclavicular space an oval, expansile mass, 3 x 2 cm was palpable. Upon auscultation, a faint, systolic bruit was audible, which radiated into the distal third of the extremity. Blood pressure in the right arm was 122/78, in the left 110/76. The radial pulse on the left was weaker than on the right, the ulnar pulse was absent.

Neurologic study noted complete involvement of the musculocutaneous nerve, an incomplete lesion of the median nerve and minimal disturbance of the radial nerve, with corresponding muscle dysfunction. There was an area of hypalgesia and anesthesia corresponding to the sensory distributions of the lateral antebrachial cutaneous and median nerves. On August 16, 1943, a false aneurysm of the first part of the left axillary artery was resected. At operation, an extensive gap in the musculocutaneous

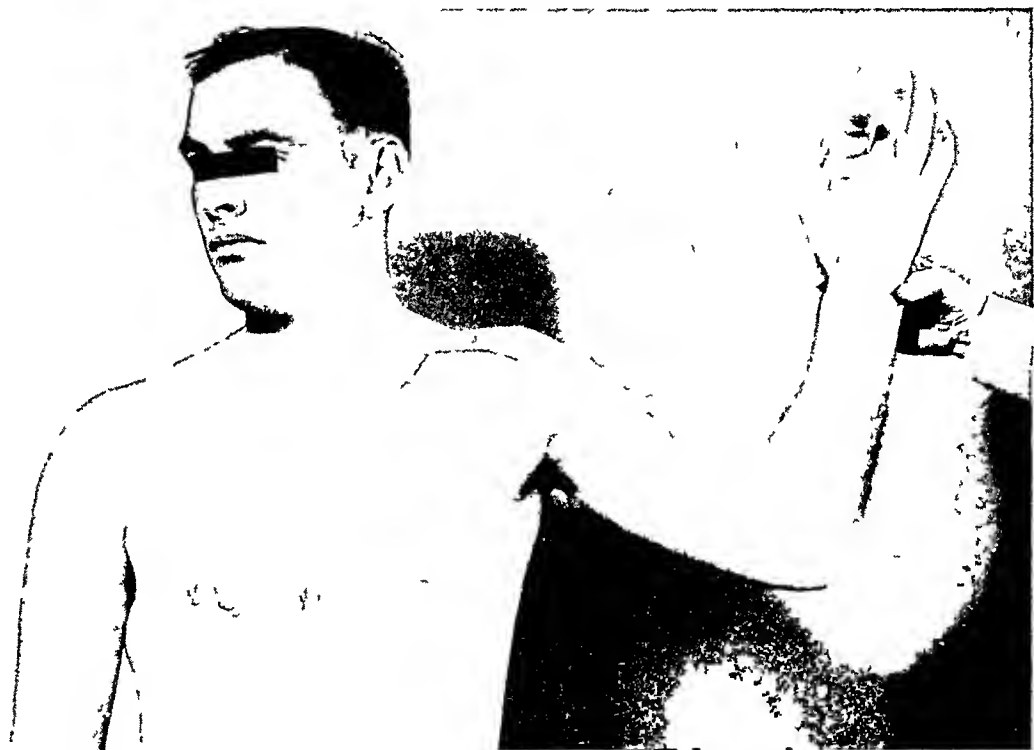


FIG 5—Case 5. Note operative approach to aneurysm of axillary artery and neural defects.

nerve was observed. The mass of the aneurysm compressed the median nerve in particular. There was no demonstrable change in the vascular supply to the extremity following operation. Beginning improvement in the neural defect is detectable at this time, three months after operation (Fig 5).

Case 6—J. K. C., Hosp. No. 4246. Rifle wound of right chest with subsequent shrapnel wound of right shoulder on April 23, 1943. Early paralysis of right arm with rapid functional recovery. Residual serratus anterior and triceps muscles paresis. Arterial aneurysm of lateral thoracic artery resected.

This soldier sustained a rifle bullet wound of the upper right chest on April 23, 1943. He remained on the field under fire until the following day when he was again injured by a shrapnel fragment in the right shoulder. At this time, the right arm was paralyzed with the hand and fingers in flexion spasm. The hand and arm recovered normal function, as far as the patient could tell, in the following two months. Chest pain persisted, and he was evacuated to the Zone of Interior.

Upon admission, October 25, 1943, a rounded, pulsating mass was palpated high in the right axilla in the course of a routine examination. It appeared to be separate

VASCULAR AND NERVE WAR INJURIES



FIG 6—Case 6 Note triceps atrophy Below, bisected aneurysm of lateral thoracic artery, showing lamination of clot

from the pulsation and course of the axillary artery A systolic nontransmitted bruit was present over the mass and both pulsation and mass could be obliterated by subclavian artery compression A small scar was present on the anterior aspect of the right shoulder Neurologic examination disclosed atrophy of the triceps muscle with associated weakness of extension of the upper arm The muscle mass of the right deltoid was diminished on the right and early abduction movement of the right arm was weak There was moderate flaring of the vertebral tip of the right scapula

On November 2, 1943, exploration of the right axilla disclosed an arterial aneurysm of the long thoracic artery measuring 4 cm in diameter. The long thoracic nerve curved around and was imbedded in the wall of the aneurysm. After resection of the aneurysm inspection of the axillary and radial nerves revealed no gross abnormality (Fig 6).

In Makins' series, nerve injuries occurred in ten of 43 instances of injury to the brachial artery. Of striking interest is the fact that only one arterio-venous aneurysm was found in Makins' patients as compared with 12 of the arterial variety. One A-V aneurysm of the brachial artery with associated nerve involvement was encountered in this series. Due to associated infection, it has not as yet been treated. A brief description of this patient is noted under Case 12.



FIG 7—Case 7 Postoperative appearance following endo-aneurysmorrhaphy of brachial artery.
Note obvious ulnar nerve deformity.

Two arterial aneurysms of the brachial artery in the antecubital space associated with nerve injury were observed. Both demonstrate the value of resection of the aneurysm as compared to endo-aneurysmorrhaphy when concomitant nerve injury is present.

Case 7—E W B, Hosp No 1403 Gunshot wound of right upper forearm. Immediate numbness of ulnar aspect of hand with weakness of intrinsic hand musculature. Obliterative endo-aneurysmorrhaphy of brachial artery with second-stage extraneural neurolysis of ulnar nerve.

This soldier was shot by a rifle bullet on March 23, 1943. The missile entered the lateral aspect of the middle third of the right forearm, traversed the arm diagonally and made its exit slightly above the medial condyle of the humerus. The wound of exit

bled profusely and a tourniquet was applied. He noticed immediately weakness of the hand grip and loss of feeling along the inner aspect of the forearm, the ulnar aspect of the hand, and the fourth and fifth fingers. There was a transient infection in the wound of exit.

Examination of the right upper extremity, May 7, 1943, showed a tubular swelling of the proximal half of the forearm with a fluctuant area 4 cm below the medial condyle of the humerus. There was a systolic pulsation together with a systolic bruit over the fluctuant area. Elsewhere the skin and subcutaneous tissues were firm and indurated without local heat or change in the overlying skin. Pressure in the region of the ulnar nerve adjacent to the wound of exit caused a tingling paresthesia. There was loss of function in the flexor carpi ulnaris and the two medial heads of the flexor digitorum profundus and the intrinsic musculature of the hand innervated by the ulnar nerve. The little finger and the ulnar aspect of the hand were analgesic and anesthetic. There was a narrow band of hypalgesia along the lateral margin of the lower half of the forearm. Obliterative endo-aneurysmorrhaphy of the brachial artery was done on May 17, 1943, with no alteration in the peripheral vascular supply to the hand. On July 14, 1943, the ulnar nerve was found divided in the thick scar tissue at the site of the aneurysmal sac. An end-to-end anastomosis was carried out with tantalum wire. No return of function is evident at the end of four months (Fig 7).

Case 8—H A B, Hosp No 3009 Gunshot wound of left forearm. Immediate numbness and weakness of hand. Arterial aneurysm of brachial artery in antecubital space. One-stage resection of aneurysm and neurolysis of ulnar and median nerves. Slow improvement in neurologic status.

This patient was shot by a .30 caliber rifle bullet on July 3, 1943. The missile entered the left forearm on its anterior and lateral aspect and emerged just above and posterior to the medial epicondyle of the humerus. He noticed immediate numbness and weakness of the hand. There was marked swelling of the elbow, forearm, and hand within two hours of the injury but there was no external hemorrhage. On the 17th day following injury, an incision was made below the antecubital space and much blood clot was evacuated. On admission, August 16, 1943, slight motion of the wrist and of the third finger had appeared. There had been no improvement in the original sensory loss.

Healed wounds of entry and exit were noted corresponding to the path of the missile. The left upper forearm was swollen and indurated. An oval mass, 6 cm in length, was palpable on the medial aspect of the forearm below the antecubital fold. There was an expansile pulsation in the mass, synchronous with cardiac systole. A loud systolic bruit was audible upon auscultation. Compression of the brachial artery in the arm caused the mass to become smaller and the bruit to disappear. The ulnar pulse was absent. The radial pulse was weaker on the left side than on the right.

Motor examination of this extremity showed disuse atrophy of the arm musculature. Minimal radial extension of the wrist was possible. Slight extension of the third finger at the metacarpophalangeal articulation was elicited. No other movements of the hand musculature were possible. There was marked contracture of the flexor tendons to all fingers. The entire hand showed cutaneous atrophy and loss of sweating. Analgesia and anesthesia were present over the sensory distributions of the ulnar and median nerves in the hand.

On September 7, 1943, the arterial aneurysm was resected. The median nerve was compressed by the mass of the aneurysmal sac and the ulnar nerve was buried in a mass of scarred, indurated muscle tissue medial to the aneurysm. It was observed that widespread muscle damage was present in the bellies of the flexor musculature of forearm. Slight improvement in the neurologic status has been evident since operation (Fig 8).

The peripheral nerve injuries visualized at operation in the preceding four patients differed grossly in but two respects from peripheral nerve injuries observed in the absence of vascular injuries. In the first place, to



FIG 8—Case 8 Arterial aneurysm of brachial artery with ulnar and median nerve paralysis Preoperative photograph Note drainage scar
(Insert) Operative specimen

the usual pathologic findings of complete or partial nerve section, contusion or compression by scar tissue, is added the factor of compression by the mass of the aneurysmal sac. It is noteworthy in these cases, and in the few recorded in detail in the earlier literature, that the neurologic defect usually appears full blown at the moment of injury. Spontaneous return of neurologic function rarely appears and operative repair of the neural pathology is mandatory. In the second place, the presence of a vascular lesion, be it arterial transection or aneurysm with concomitant nerve injury, tends to exaggerate and make permanent the existing neural dysfunction through local and general alteration in the nutrition of muscle fibers. The frozen, contracted hand, resulting from acute arterial occlusion is well recognized, and if this deleterious factor be added to a neural defect, the resulting deformity may be irremediable.

It is of interest that in Case 7 the question of abscess formation rather

than arterial aneurysm was considered, and in Case 8 actual incision was done. In Fromme's Cases 1 and 25, similar supposed abscesses were incised with resultant severe hemorrhages, and in Case 46, identical with the last two of this series, the diagnosis of abscess was entertained briefly.

Finally, it may be stated, unequivocally, that a single, inclusive surgical approach to the vascular and the neural lesions is preferable to surgical repair of either lesion at separate operations.

III—VESSEL AND NERVE INJURIES OF THE LOWER EXTREMITY

Peripheral nerve injuries occur with arterial or arteriovenous aneurysms of the lower extremity but with less frequency than with those of the upper extremity and neck. They may involve the sciatic nerve in traversing wounds of the thigh and the peroneal and tibial components in large, open wounds of the popliteal space. In only five of 85 instances of popliteal artery injury were neural structures involved in Makins' series, and the incidence in other major reports is correspondingly low.

Case 9—J C B, Hosp No 2109 Machine gun wound of left femoral region. Immediate paralysis and loss of sensation in extremity with rapid return of function. Resection of A-V aneurysm of common and deep femoral artery and vein.

This officer was struck in the left femoral region with a machine gun bullet on April 29, 1943. A perforating wound of the thigh was sustained with the wound of exit in the left buttock. This extremity was paralyzed and made anesthetic at the time of impact, but motor and sensory defects cleared within a few hours. A profuse external hemorrhage occurred, which was controlled by pressure. There was no evidence of circulatory deficiency, but pain in the calf and popliteal space developed early. This distress increased with the appearance of a harsh bruit over the femoral triangle, of dilated leg veins and some peripheral cyanosis. On June 11, 1943, the left femoral artery and vein were ligated proximal to the fistula without alteration in the peripheral circulation and without effect upon the aneurysm. At this time, cardiac studies were normal.

Upon admission, July 11, 1943, examination showed induration in the left femoral triangle. About 8 cm below Poupart's ligament was a small wound of entry beneath and lateral to a well-healed surgical incision. A second surgical incision was situated lateral to the first. The scar representing the wound of exit was noted in the left buttock. Beneath the larger incision a loud, harsh bruit was audible throughout systole and diastole, accentuated during the former phase. Occlusion of the femoral artery above the fistula diminished but did not cause the bruit to disappear. Such occlusion caused a transitory slowing of the pulse rate. The peripheral pulses were absent in this extremity and there was slight, dependent cyanosis of the foot. There was definite enlargement of the heart to the left, confirmed by fluoroscopy. Neurologic examination demonstrated only a diminution of the left knee kick and weakness in dorsiflexion of the left great toe. There were no sensory changes. The left sciatic nerve was somewhat tender and pressure over it increased the peripheral pain.

On August 4, 1943, quadruple ligation and resection of the arteriovenous fistula was performed. His convalescence was uneventful and the radiating pain slowly diminished.

Case 10—M J R, Hosp No 2957 Multiple injuries of trunk and extremities from land mine, including extensive laceration of right popliteal space. Development of popliteal A-V aneurysm with involvement of lateral cutaneous sural nerve. Quadruple ligation and excision of aneurysm, neurolisis.

This officer in the Medical Corps received multiple injuries of the trunk, abdomen, upper and lower extremities from the explosion of a land mine in April, 1943. He re-

remained dazed and disoriented for several days as the result of blast concussion. At this time he recognized the presence of a right ulnar nerve paralysis and appreciated an area of numbness over the lateral aspect of the right lower leg. He stated that there was a profuse hemorrhage from a broad laceration of the right popliteal space at the time of injury, necessitating several plasma and whole blood transfusions. One month following the injury, the ulnar nerve paralysis began to recede. At this time, he became conscious of a continuous thrill in the popliteal space and was the first to recognize the presence of arteriovenous aneurysm of the popliteal vessels. He noticed no symptoms referable to cardiac strain except shortness of breath, and he did not feel that the peripheral blood supply to the involved extremity was impaired.

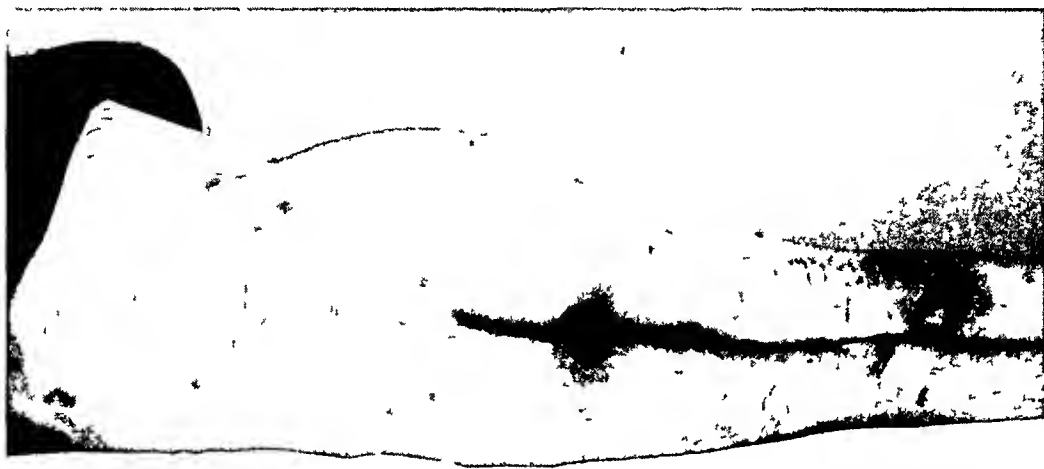


FIG 9—Case 10. Multiple injuries from explosion of land mine. Postoperative photograph, following excision of popliteal A-V fistula.

Examination was noteworthy for the presence of 28 separate scars over the posterior surface of the trunk and lower extremities, characteristic of multiple injuries from the explosion of an antipersonnel land mine (Fig 9). Over the inferior aspect of the right popliteal space was a broad, irregular scar, extending laterally beneath the tibial tubercle. Above this scar and rather high in the popliteal space the tissues appeared full. Upon palpation at this point, a strong continuous thrill could be felt, and upon auscultation, the bruit was continuous but accentuated with systole. There was no evidence of cardiac damage and the peripheral blood supply of the foot was normal. Hypalgesia and hypesthesia were present over the sensory distribution of the lateral cutaneous sural nerve. There was no evidence of motor dysfunction in this extremity. Neurologic study elsewhere disclosed only hypalgesia over the cutaneous area innervated by the ulnar branch of the medial antibrachial cutaneous nerve. On August 24, 1943, the arteriovenous aneurysm was excised after quadruple ligation. At operation, the peroneal nerve was compressed by scar tissue and an external neurolysis was done. The neurologic defect has improved steadily and he has returned to duty.

CASE 11—P. W. P., Hosp. No. 3008. Shrapnel wounds of right popliteal space May 5, 1943. Profuse hemorrhage, leg pain and diminished peripheral circulation. Lumbar sympathectomy with improvement in circulation. Resection of popliteal A-V aneurysm. Normal neurologic examination.

This soldier received wounds of the right knee, leg and left shoulder from fragments of an 88 mm shell on May 5, 1943. Profuse hemorrhage occurred from a wound in the right popliteal space which was debrided and the hemorrhage controlled. No injury to major vascular or neural structures was reported. The right lower leg and foot remained cold and cyanotic, with considerable aching pain. On July 17, 1943, a right lumbar sympathetic ganglionectomy was carried out with partial relief of pain, and considerable improvement in the peripheral circulation.

Upon admission, August 29, 1943, there was a flat, healed scar in the right popliteal space and a second operative scar in the posterior upper third of the calf. A shrill bruit was audible over the popliteal space, extending throughout systole and diastole and accentuated during the former. Occlusion of the fistula did not change the pulse rate. The right posterior tibial pulse was absent, but the right foot was warmer than the left. There were no abnormal cardiac findings. Neurologic examination was normal (Fig 10).

On September 6, 1943, quadruple ligation and excision of the arteriovenous aneurysm was done. There was no change in the peripheral circulation and his convalescence was uneventful. The tibial and peroneal nerves, although closely adherent to the fistulous mass, appeared normal at operation.

Case 12—S M, Hosp No 3528
Multiple wounds of right arm, chest and left leg on July 11, 1943. A-V aneurysms of left femoral and right brachial vessels. Minimal hypalgesia in left popliteal space. Quadruple ligation and an excision of femoral A-V fistula with aneurysmal sac on September 7, 1943.

This patient, in brief review, developed an arteriovenous aneurysm of the right brachial artery, upper third, and a comminuted compound fracture of the right elbow, with associated nerve injuries and an A-V aneurysm of the left femoral vessels.

Upon admission to this hospital, a pulsating, expansile mass was noted on the superior and medial aspect of the left thigh. There was a palpable thrill and audible bruit lasting throughout systole and diastole, with systolic accentuation. Occlusion of the fistula did not alter the pulse rate. The peripheral circulation was adequate and there was no evidence of cardiac damage except a constant elevation of the pulse rate (110 per min). Neurologic examination showed, in this extremity, only hypalgesia and hypesthesia in the popliteal space, suggesting involvement of some of the fibers of the posterior femoral cutaneous nerve. Quadruple ligation and resection of the fistula and adjacent aneurysmal sac were carried out on September 7, 1943. His convalescence was uneventful from this localized disturbance. Operation upon the brachial aneurysm has not yet been carried out because of local infection in the associated compound fracture (Fig 11).

SUMMARY

It appears probable that more vascular and nerve injuries of various types will be seen in this war than in World War I, because of improved methods for the control of shock and infection and because of the increased incidence of multiple injuries.

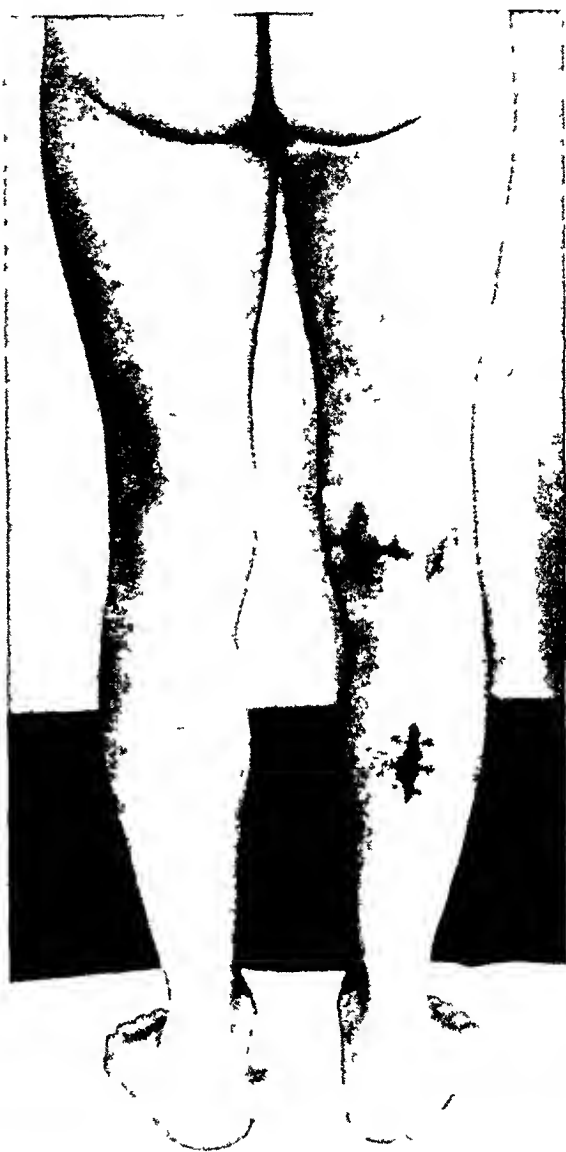


FIG 10—Case 11. Preoperative photograph of popliteal arterio-venous aneurysm.

The diagnosis and treatment of aneurysms and peripheral nerve trauma have not been discussed in this paper. However, it should be pointed out that certain basic principles in the treatment of aneurysms must be observed or else failure is sure to follow. For example, the treatment of aneurysm, whether it be arterial or arteriovenous, is never a matter of emergency unless it is rapidly progressing in size or has ruptured, or unless heart failure is impending. Time should be allowed for collateral circulation to develop, usually a matter of three or four months. The use of artificial means to develop collateral circulation, usually proximal compression of the vessels, should be employed. Moreover, the eradication of an arteriovenous fistula

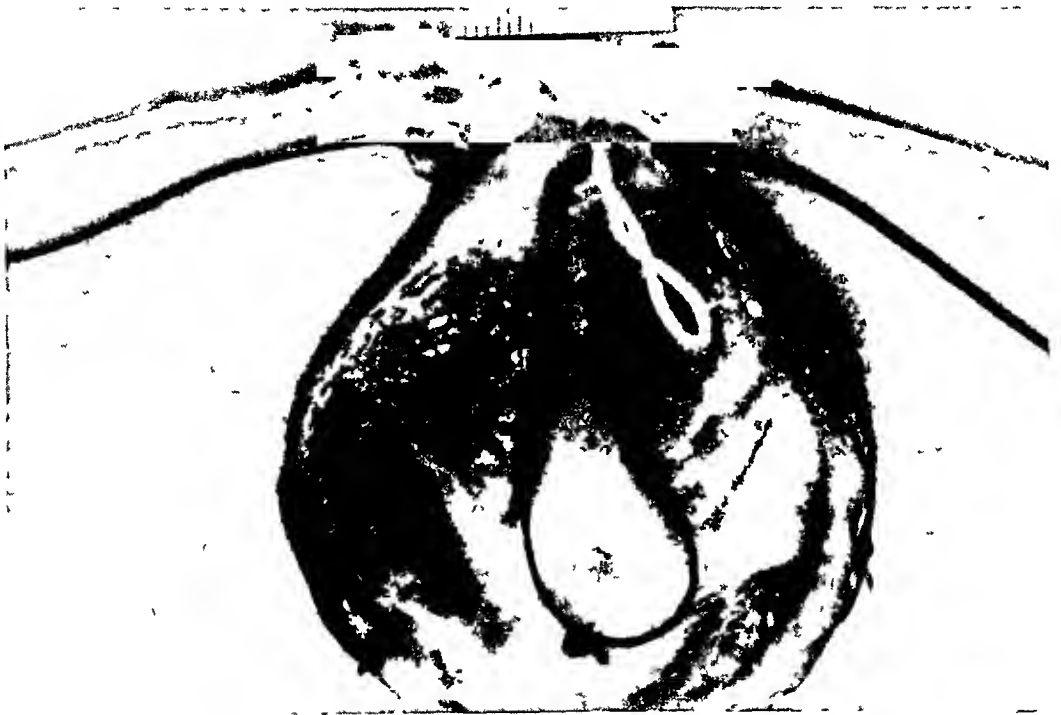


FIG. 11—Case 12. A-V fistula with communicating arterial sac. Note white string in artery and black string in vein.

is accomplished only by quadruple ligation and excision. Any other method usually results in recurrence. Partial measures, such as proximal ligation of the artery, may lead to gangrene of an extremity. Complete excision of an arterial aneurysm, together with nerve repair, as a single operative procedure, is the method of choice. When major vessels are involved and where the nutrition to the extremity is questionable, the endo-aneurysmorrhaphy of Matas is preferable. This applies particularly to the common femoral and other major arteries.

It is well recognized in all peripheral nerve surgery that a conservative attitude should be taken regarding technical procedures. This is particularly important in injuries associated with blood vessel trauma because of the added factor of compression by an aneurysm. This factor, producing added nerve damage in the false aneurysm, is not often present in arteriovenous fistulae, which are rarely large enough to produce pressure damage. Nerve injury

must occur at the time of formation of the fistula, through the same inflicting force, and may be due to concussion, contusion, or to actual section of nervous tissue

In many instances, at the time of the original injury, there is evidence of extensive nerve damage. By the time that vascular repair is indicated, the neural damage may have resolved itself to a large extent, leaving a residual neurologic defect, which may be repaired at the time of operation upon the blood vessel.

Recognizing the slowness with which nerve regeneration takes place and desirous not only of attaining the best functional result, but also of making studies for future reference and treatment, the Surgeon General has adopted a policy of treating all peripheral nerve lesions until maximum hospital benefit has been obtained. Even where soldiers are returned to duty, they are ordered back to the hospital where last treated for periods of observation every three months.

Finally, it is emphasized that the traumatic syndrome of Vernet and Villaret, *viz*, involvement of the last four cranial nerves, is often associated with blood vessel damage in the neck due to the close proximity of these tissues.

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CONTROL OF PAIN IN POSTTRAUMATIC AND OTHER VASCULAR DISTURBANCES*

THE RÔLE OF THE SYMPATHETIC NERVOUS SYSTEM IN THE TREATMENT OF PERIPHERAL VASCULAR DISEASES

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THE RÔLE of the sympathetic nervous system in the treatment of vascular diseases is very controversial. Much knowledge concerning the functions of the sympathetic nervous system has been acquired from clinical trial which initially deserved only the title of clinical experimentation. Perhaps this appearance of much of Leriche's work led to incredulence and delayed acceptance. One of the most controversial of all phases of the sympathetic nervous system, is the part it plays in pain, especially deep pains of the vessels, bones and muscles. No animal experimentation has advanced knowledge so well as clinical experiments in this field. No absolute conclusion is justifiable regarding such pain and the sympathetic nervous system, but it is surprising what may happen with regard to certain pains when the sympathetic nerves are interrupted.

MATERIAL

On my private services at the Touro Infirmary and Baptist Hospital, 62 patients have been admitted whose condition demanded temporary or permanent interruption of the sympathetic nervous system. These cases have given opportunities for much clinical investigation. The diagnoses in the different cases were as follows:

Raynaud's disease	4
Posttraumatic syndrome	19
(pain, edema, causalgia, Sudeck's atrophy)	
Thrombo-angitis obliterans	14
Thrombophlebitis or postthrombophlebitic edema	20
Arteriosclerosis	3
Hyperhidrosis unilateralis	1
Herpes zoster	1
	—
	62

Twenty-two operations were performed to permanently interrupt the sympathetic nervous system. Eleven of these were lumbar ganglionectomies and 11 were preganglionic sections of the dorsocervical sympathetic nerve trunk for the upper extremities. The dorsocervical operation was performed seven times for the posttraumatic syndrome and four times in two patients for Raynaud's disease. Lumbar ganglionectomy was performed nine times (in eight patients) for thrombo-angitis obliterans and twice for postthrombophlebitic edema.

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The pains of vascular diseases are varied in cause and type. In many vascular diseases, pain is the predominant, sometimes even the only disabling symptom. Measures which relieve the pain even though they may not return the vascular system to normal, may rehabilitate the patient to an extent which permits a useful if not a very active existence. Too frequently, the diagnosis of an arterial vascular disease excites predominant thoughts of impending gangrene and its prevention, when in reality, lesser degrees of arterial obstruction or spasm not converging on a state of gangrene, may produce very severe painful symptoms which disable to the extent that the patient is a liability instead of an asset to himself and his family. With pain, a man with a severe arterial impairment, occlusive or vasospastic, may restrict his activities and live a very plausible existence, but with constant pain, he becomes totally disabled. Most of the pains in vascular diseases are diffuse, deep, often intense, and there are some reasons to believe that the sympathetic nervous system plays a large part directly or indirectly in the transmission of such pain.

Edema, a cold clammy hand or foot, and "poor circulation" associated with pain or soreness, may persist for a surprisingly long time after an injury remaining as the only vestige of the injury to mar what might be judged otherwise a perfect result. The vascular changes occurring after trauma are not fully appreciated. Fractures and major soft tissue injuries, and even certain minor injuries may be followed not only by the immediate changes in the vascular system, but also by vascular changes which are chronic and persistent. These changes are vasodilatation or vasoconstriction or both. Whether the pain or vasospasm is antecedent or whether they are concomitant and not cause and effect, has not been determined, nor is the nature of this pain well understood. The coldness and "poor circulation" may be sub-clinical, only detectible by a precision instrument such as a thermocouple (dermo-therm). Joint stiffness may linger not because of ankylosis, but because edema and swelling around the capsule and pain on attempted motion is so severe, a residual which could be quickly obviated without the pain, is prolonged because of it. This pain of joints is similar in some respects to the other pains of causalgia and Sudeck's atrophy.

The pain of other vascular diseases simulates in many instances that of the posttraumatic syndrome. The severe rest pain of thrombo-angitis obliterans is explainable not only by ischemia. If so it would be at first most peripheral and advance upward as the ischemia progresses. Instead it often begins in the middle of the foot. Spasm of the vessel itself and not the resulting ischemia may be responsible for pain. The kinetic pain or claudication may be entirely different. The pain of Raynaud's disease is most intense, the most disabling part of the disease. Its relief seems to be proportionate to the relief of vasospasm. When we have been taught to think the conveyance of pain, all pain, is the property of somatic nerves, it is too violent a change to have to accept easily, the possibility that another type of nerve namely the sympathetic system, may convey severe pain.

Leriche maintains the pain is conveyed by the sympathetic nerves. Davis and Pollock think it is carried over the somatic nerve, but that the irritated sympathetic nerves cause a metabolic product which excites pain sensation in the sensory nerves. Miller and de Takats, after careful plethysmograph studies, concluded that vasodilatation occurs in some cases and vasoconstriction occurs in others. They conjectured that vasoconstriction may occur in the finer vessels while vasodilatation is occurring in the larger.

It is difficult to classify clinically sympathetic nerve system pains. There are at least four or five groups: (1) Posttraumatic pain, (2) Causalgia, (3) Sudeck's atrophy, (4) Sympathalgia, (5) Nontraumatic reflex vasospasm (from inflammation, thrombosis, embolus, etc.).

Under this classification, posttraumatic pain is a condition in which the objective findings are minimal with subclinical vasospasm and possibly edema. Causalgia portends pain with more objective findings, edema, paresis of a nerve and sometimes pain only in the distribution of a nerve. In Sudeck's atrophy, pain is associated with an osteoporosis. Sympathalgia is sympathetic nerve pain not necessarily associated with traumatic onset. Another group of painful conditions associated with vasospasm but not caused by external trauma are those of inflammation, embolus, thrombosis, and similar causes.

Whatsoever be the phenomena associated with posttraumatic pain, it is true that interruption of the sympathetic pathways by infiltration with novocain, or by surgical section, usually dramatically relieves the patient. Moreover the pains of other vascular diseases may be relieved by sympathetic interruption. What relief of pain is afforded purely by the relief of vasospasm is debatable. It is feasible to shorten the convalescence of patients with persistent pain following injury by repeated paravertebral sympathetic nerve blocks or if warranted by surgical section of the sympathetic nerves. By sympathetic nerve block is meant infiltrating the region of the sympathetic ganglia with novocain, *etc.*, in the region of the stellate and the second and third dorsal ganglia for the upper extremity or through four needles placed adjacent to the vertebral bodies in the 1st, 2nd, 3rd, and 4th lumbar interspaces for the lower extremity. A few examples will explain better what is meant by such therapy.

(1) A man, age 41, came under observation 19 weeks after an accident in which he sustained a supracondylar fracture of the left forearm. Even immediately after the plaster encasement was applied, he had severe persisting pain in the arm and hand. The encasement had been removed six weeks after the accident, and his arm and hand remained stiff and painful. Examination revealed a condition which resembled the early picture of Volkmann's ischemic contracture, a stiff hand, wrist, fingers and elbow. The elbow motion was not more than 20°. The motion of the fingers and wrist not more than 10°. Moreover there was edema of the forearm and hand, atrophy of the muscles, and extreme pain on the slightest motion of the joints. He had received physiotherapy elsewhere, but the intense pain prevented any active mobilization of the joints.

Repeated paravertebral sympathetic nerve blocks with novocain were done. Each time one was done, in addition to the Horner's syndrome, the hand became warm and there was a dramatic relief of pain even on forced motion of the joints. This relief of pain lasted all of one day and it returned to a lesser extent on the following day. The joints were quickly mobilized and after three weeks he was dismissed from the hospital with comparatively little limitation of motion in the joints. Eventually function returned so completely to the muscles and joints, that the result could be regarded as practically perfect.

In this instance operation to section the sympathetic nerve may have been justifiable, but the result could not have been better following operation. This also illustrates the value of repeated temporary sympathetic nerve interruption in patients with early Volkmann's ischemic contracture.

(2) A carpenter age 38 caught the terminal phalanges of the index and middle finger of his left hand in a machine. Compound fractures of the terminal phalanges resulted and both fingers were badly contused and lacerated. The end of the third finger was almost amputated. This was sewed on and in due time the wounds healed and union of bone resulted. Even after eight weeks however the severely scarred fingers were so sensitive he could not return to work. (Plate I, b1 and b2) They were hyperesthetic to the extent that he could not hold a nail and even putting his hand in his pocket caused so much pain in the hypersensitive fingers and tender scar, that he refrained from doing it. He was emotionally stable and by no means was he a malingerer. At this phase of his convalescence pain alone was obstructing his return to work. Then (at the end of eight weeks) the dorsocervical sympathetic chain was blocked with novocain by the Leriche method. With the patient recumbent, a pillow under the shoulders and the head slightly hyperextended and rotated to the opposite side, a wheal was made one finger's breadth above the junction of the inner and middle third of the clavicle. A No. 24-gauge spinal needle was inserted through the skin wheal and in the coronal plane, and at a 45° divergence from the sagittal plane, so that the needle went backward and inward slowly until it struck bone—the lateral surface of the body of the first dorsal vertebrae. After aspirating and obtaining nothing through the syringe, five cubic centimeters of one per cent novocain was injected. Then the point of the needle was withdrawn and in the same oblique plane, the butt of the needle was deviated cephalad in order to throw the point farther down onto the body of the 2nd dorsal vertebra as it was reinserted. The needle was changed in the coronal plane several times to strike the first or second rib and infiltrate the gutter between the ribs and the lateral surfaces of the first two vertebra. Ten cubic centimeters of novocain was delivered. A Horner's syndrome developed within two or three minutes and within five to ten minutes, the hand of that side was warmer even, and drier, than the opposite hand. The hyperesthesia and tenderness of the fingers dramatically vanished and it was possible to press the injured finger tips where 15 minutes before they were so sensitive, he could not stand the lightest touch. The

scarred area remained less sensitive all that day. The next day the pain returned, but to a far less extent. His finger remained much better than it had been. One week following the first sympathetic nerve block, another block was performed. This time the hyperesthesia disappeared entirely. It returned to a minor extent only, so that he could handle nails and do his work. He returned to work a few days thereafter, and his disability was shortened by weeks.

(3) This case is an example of one in which preganglionic sympathectomy was judged advisable for relief of causalgia, a pain following a previous operation. A woman, age 29, had severe pain in her left arm, which was more pronounced in the region of a scar on the anteromesial aspect of the forearm (Plate I C1 and C2). Two years ago, in another city, a small mass was removed from the forearm. It recurred and after a few months it was removed again. She was told it was a neurofibroma. Ever since then, the scar has been extremely sensitive and pain radiates up and down the arm. The scar was very tender and pressure on it caused a pain to shoot up and down the ulna side of the arm. Examination failed to reveal any mass in the arm. A roentgenogram showed a rudimentary cervical rib. Considerations in the diagnosis included, scalenus anticus syndrome, recurrent neurofibroma, and causalgia. A sympathetic nerve block was performed. A Horner's syndrome developed, and the pain was completely relieved and tenderness of the scar disappeared, but, all symptoms returned with severity the next day.

Several days later, the following operation was performed. The area under the scar was explored, no mass was found. A small amount of scar was removed. The ulna nerve was found to be normal. Because these findings were expected, the patient had been draped so that a dorsocervical preganglionic sympathectomy could be done immediately. Through an anterior approach the scalenus anticus muscle was severed. The dorsal sympathetic chain was severed below the third dorsal ganglion and the rami communicantes to the second and third dorsal ganglia were severed. The proximal end of the nerve trunk was sutured to the scalenus medius. The rami communicantes to the stellate ganglion were left intact. The patient was completely and permanently relieved of her pain. The left hand and arm remained warm and she did not develop a Horner's syndrome because the rami communicantes to the stellate ganglion were not disturbed.

In these and similar cases interruption of the sympathetic nerve system by repeated novocain blocks or by surgical section may prove of tremendous value in restoring the patient to normal. The question as to how often to do the novocain blocks depends on the case. It is rare that one block will give permanent relief for a condition which justifies its being done at all. As a tentative routine plan, I prefer to block the nerve every other day.

PLATE I

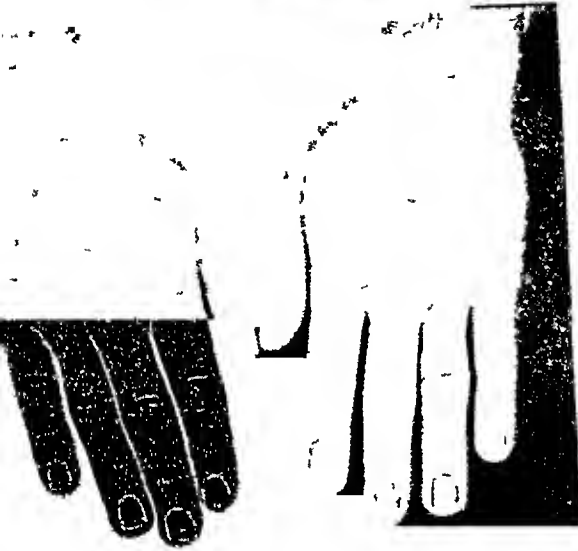
A1 Man age 30. Three months prior to this his arm was caught in a conveyor belt. When first seen he had edema and pain in arm with markedly stiff and painful joints. A2 after repeated paravertebral sympathetic nerve blocks which helped to clear the edema and permitted mobilization of the joints. End result not perfect, but good enough to permit him to return to his former job 'pushing long iron rods' in a container factory.

B1 and B2 injury to index and middle fingers left him with hyperesthesia and extremely sensitive scars. Paravertebral sympathetic nerve blocks promptly relieved the pain and paresthesia. (See text).

C1 and C2 A woman age 29 with causalgia of left arm. Exploration of forearm through old scar revealed no local cause. Preganglionic dorsocervical sympathectomy resulted in relief of pain.



A



B



for three times, then if necessary, every third day for an additional time or two. As for alcohol, the danger of neuritis precludes its use in the dorso-cervical region. Even in the lumbar region it may produce neuritis. Moreover, alcoholic injection is inefficient. True, it may produce some prolonged vasodilatation, but the effect is less marked than that immediately following novocain infiltration and is certainly less marked than following surgical extirpation. Either repeated sympathetic novocain blocks accomplish the desired result, or, if more permanent, more complete vasodilatation is desired, operation is indicated. Sympathectomy is a relatively safe operation, as safe as appendectomy, and its recovery period is equally short.

It is difficult to clearly designate the indications for preganglionic section of the sympathetic nervous system for the relief of pain. Such varieties of conditions are involved that it obviously is a problem to be individually solved for the patient in question. In general, however, operation is not indicated in instances where a few repeated sympathetic nerve blocks accomplish the desired result, and operation is never indicated for relief of a pain which sympathetic nerve block does not temporarily mitigate or completely abolish. The operative approach for preganglionic section of the dorsocervical sympathetic nerves (third and second dorsal and stellate ganglia) may be from behind (Smithwick) or the front. Though each has its advantages (perhaps the posterior approach affords the most room), I have used the anterior approach more frequently. This is the operation described by Telford, in 1935. The sympathetic nerve trunk is severed below the third dorsal ganglion. The rami communicantes to the second and third ganglia are severed. I sew the proximal end of the nerve trunk to the scalenus medius muscle. It is my experience that in the posttraumatic syndrome preganglionic sympathetic nerve section is followed by a persisting warm and dry extremity but not so in Raynaud's disease where vasospasm is more apt to recur. The uniformity of persisting vasodilatation following sympathectomy for causalgia and the uncertainty of its duration following the same procedure in Raynaud's disease is evidence against Raynaud's disease being a fault of the sympathetic nerve trunk.

After preganglionic section of the dorsocervical sympathetics for causalgia, the upper extremity remains warm and dry indefinitely. The vasodilatation measured by the thermocouple is a little less marked after seven days than it is on the first day, but it still remains warmer than the opposite extremity. In Raynaud's disease the result is not similar. In the latter disease, preganglionic section of the sympathetics may be followed by a recurrence of the vasospasm—in ten days, two weeks, six weeks, and the time of its occurrence may be determined largely by the first exposure of the patient to cold. It is not regeneration of nerves which makes the difference. It is difficult to believe that regeneration occurs in Raynaud's disease only, and not after, preganglionic nerve section for causalgia. The fact that an operation which will cause permanent vasodilatation in a person who is relatively normal and is followed by a recurrence of vasoconstriction of finer terminal arterioles and capillaries in Raynaud's disease, is evidence in favor of the belief that

the cause does not act through the sympathetic nerve outflow, but by a local or circulating factor which overcomes the tendency to vasodilatation following sympathectomy. It is my experience that the vasodilatation following pre-ganglionic section for Raynaud's disease persists in the skin of the arm but diminishes in the extreme part of the upper extremity, *i.e.*, the fingers. Moreover, the larger arteries pulsate well and fully and are not under the influence of vasospasm, whereas, the extremely fine arteries of the fingers are under the most

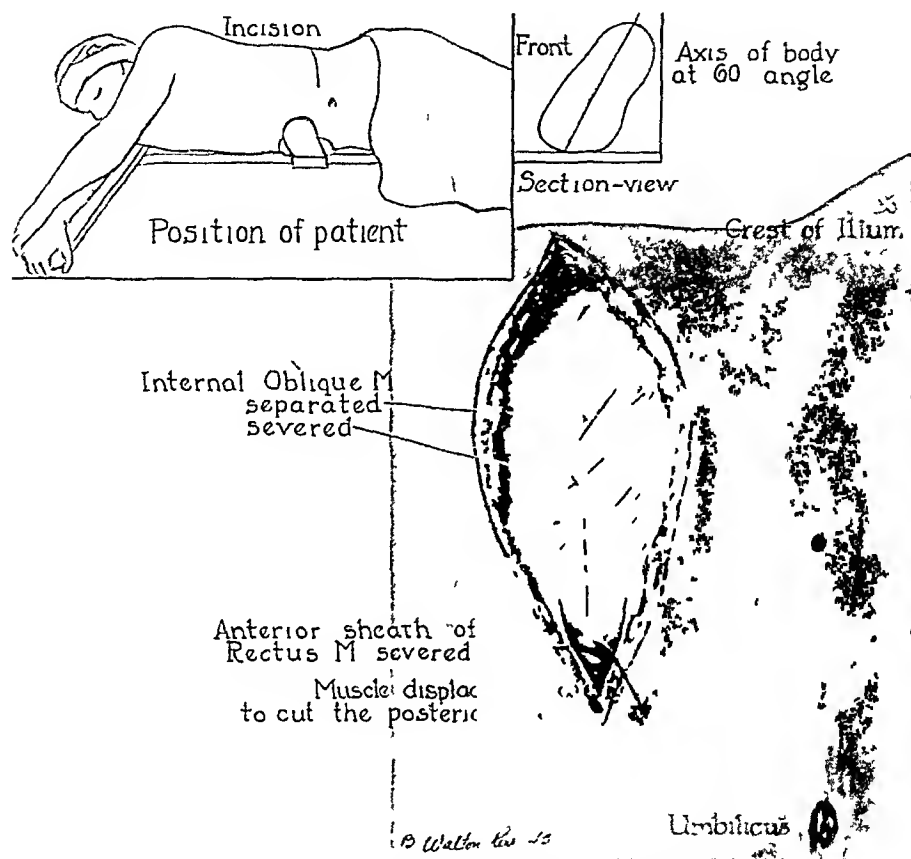


FIG 1—Lumbar sympathetic ganglionectomy. Patient in lateral position and axis of body tilted backwards. Needles are placed posteriorly at the first lumbar interspace and at the fourth lumbar interspace just as for paravertebral sympathetic nerve block. These serve as landmarks for the second to fourth lumbar ganglia. Incision is made from the eleventh rib forward to just above the umbilicus. The aponeurosis and fibers of the external oblique are severed in the line of incision.

intense vasospasm and the fingers are very painful. Moreover, sudomotor function after the same type of sympathectomy remains paralyzed which is evidence indicating that it is not the type of operation which fails, but that it is the type of disease which makes it fail. Raynaud's disease appears not to be fundamental disturbance of the sympathetic nervous system. Lewis, following careful studies, believed the condition to be a local fault. The release of the normal sympathetic nerve function does cause a temporary vasodilatation, but it does not attack the seat of the disease. Sympathetic nerve interruption is so far away from the true cause of Raynaud's disease that probably the operation eventually will be given up altogether for that condition when the etiologic factor is discovered.

NOTES ON THROMBO-ANGIITIS OBLITERANS

Buerger's disease is one of the most terrible afflictions which may beset a young man. It disables by pain, a fact which is too infrequently appreciated. A patient with Buerger's disease may be able to walk six blocks and then have to stop because of the pain (intermittent claudication). Even with this much vascular reserve, the dorsalis pedis and posterior tibial arteries are pulseless. The claudication, however, is not what impresses the patient so much. It is the rest pain, the boring, aching, intense pain in the ball of the foot, in a toe or in the instep which annoys him and keeps him awake at night and which disables so much. He could work at many jobs with a claudication which stops him only after three or six blocks, but he can work at none with the rest pain which nightly keeps him awake.

Gangrene or impending gangrene is a late stage of Buerger's disease. Usually the patient has had the disease a year or two before this complication supervenes. In the earlier stages it is easier to accomplish much more for the patient. For example in three cases these were the results:

A man, age 50 could slowly walk three blocks without claudication. Ganglionectomy not only abolished his rest pain, but increased his vascular reserve so that he can walk ten blocks.

A man, age 37 could slowly walk six blocks without claudication. Pain at rest was considerable and he had a small gangrenous spot on the plantar surface of his foot. Bilateral lumbar sympathectomy increased his vascular reserve so that he could walk sixteen blocks. The rest pain disappeared and the gangrenous spot healed.

A man, age 52, who had lost his left leg from gangrene two years previously, could walk using his artificial leg one-half block before claudication in the remaining leg stopped him. He had severe rest pain which made him accept sympathectomy. The operation relieved his rest pain, but increased his vascular reserve only so much that he could walk one block.

In each instance the foot pulses were absent, color changes, and other objective evidence for Buerger's disease were present. The first two were early, the last was a late stage of Buerger's disease. All three patients returned to work. If the vascular reserve was roughly measured in the distance walked without claudication, it was increased two and one-half times in the patient with early thrombo-angiitis obliterans but less than twice in the one with late Buerger's disease. In the early cases, however, the increase was appreciable, seven blocks and ten blocks, whereas in the late case the improvement afforded a very short increase in distance. Such good results in my experience persist, if the patient's cooperation in not smoking is obtained.

It is my impression that Buerger's disease runs a self limited course. The organic changes seem to progress for two or three years then the disease stops and does not progress or proceeds at a much diminished rate. This is encouraging because if the patient can be tided over this phase with minimum organic changes in his vessels, he may then continue to lead a comfortable, useful, though a restricted, life.

Numerous drugs have been tried in this condition, few have given any definitely convincing evidence of their therapeutic value. Working on the theory that the disease so rare in women, might be favorably influenced by estrogenic hormone, I have used stilbestrol administered orally in daily one milligram doses in six cases. My impression is that it helps in combating the progress of the disease. It seems to retard the disease. None of these



FIG 2—Fibers of the internal oblique muscles are partially severed and partially separated. Those of the transversalis muscle are spread.

patients have developed gangrene and all are returned to a useful working life. All had stopped because they could not work. In each instance, however, the treatment included other measures and in each patient sympathetic nerve surgery.

The indications for operation on the sympathetic nerve system in thrombo-angitis have never been standardized. Brown and Adson, in 1926, attempted to show a workable standard equation by comparing the rise in the skin temperature of the extremity with rise in body temperature induced by

intravenous injection of typhoid bacilli. I have measured the temperature of the skin at various places on the leg and foot and of each of the toes daily following ganglionectomy. Toes which were colder before operation became 4°C warmer on the side operated upon. When the patient developed fever to 102°F , the toes on the side operated upon remain 4°C warmer than those of the opposite foot, though the temperatures of each side had increased. This showed that even in fever the vasoconstrictor factor was present on the unoperated side and aside from the fact that the vasomotor index is no longer determined because of the disadvantages of the febrile reaction it did not show a true release of vasoconstriction as was formerly thought.

Various measures have been advocated for testing the vasomotor release expected from ganglionectomy usually by skin temperature studies and oscillometer studies after injecting peripheral nerves and infiltrating sympathetic ganglia as advocated by White. Though other ways such as warming the body, spinal anesthesia and novocain block of mixed nerves have been used to cause vasodilatation the most accurate test seems to be paravertebral sympathetic block and measurement of the skin temperatures by a thermocouple. My experience is that the oscillometer is of no value and that far from being an instrument of precision, it is never able to measure the minute increments of variation found after sympathetic nerve blocks in Buerger's disease. On the other hand, thermocouple readings before and after sympathetic nerve blocks may predict with fair accuracy this change to be expected after ganglionectomy. If a rise of 4°C is obtained after sympathectomy comparing this figure with the preoperative rise after sympathetic blocks will usually show that the blocks predicted the postoperative temperature within from 0.5° to 2°C .

In measuring comparative temperatures of the skin by thermocouple, it is essential to employ definite areas on the thigh, leg, ankle, foot and on each toe. The measurements should be bilateral. The toes will show the greatest increment of temperature change. Their temperature may rise 3°C while the leg rises 1°C . The greatest increase after nerve blocks will occur in from 20 to 30 minutes. Increases of 5°C may be seen, but rises of even less than 0.5°C do not mean that ganglionectomy will not be of value. A patient who had severe thrombo-angitis obliterans, had a rise of only 0.25°C in the toes following two sympathetic nerve blocks. Measurements made on the eighth postoperative day showed the toes to be 2°C warmer than they were at the same room temperature prior to the operation. Even though very little increase in actual temperature of the extremity is obtained by operation—which would indicate a disappointing increase in the blood supply to the extremity—much is gained in pain relief for here again the surprising benefit of pain mitigated or abolished by sympathetic nerve section has no experimental proof but clinically it works.

Upon what then may the indications for operation (sympathectomy) in Buerger's disease depend? Upon the age and the condition of the patient. Sympathectomy offers so much to the early case that it seems always justified when the diagnosis is made in young people. The pulses in the foot however,

must be absent to justify a certain diagnosis. All patients under 50 years of age deserve operation unless gangrene makes the leg untenable and all patients between 50 and 60 deserve careful clinical consideration and an attempted evaluation of the expected improvement by sympathetic nerve blocks. Even patients aged 60 years, and over, have surprising vascular resiliency sometimes showing at age 65— 2° C rise in the temperature of the toes after sympathetic nerve block. Even though it is not justifiable to omit reasonable

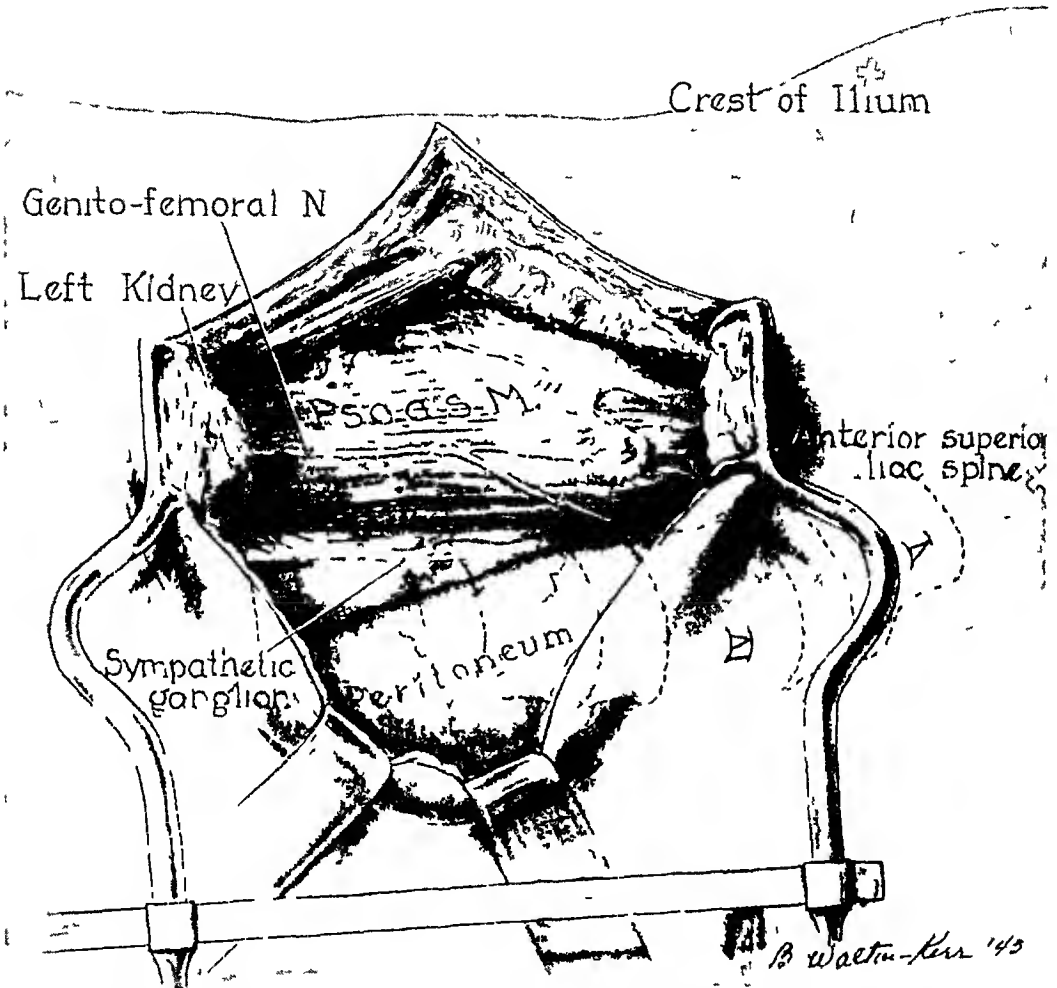


FIG 3—After pushing the peritoneum downward and forward the ganglionated trunk is located in the valley between the vertebral body and the source muscle. Needles placed as for lumbar sympathetic block prior to the operation served as landmarks of the first interspace and fourth interspace. The lumbar chain is removed from the second through the fourth lumbar segments.

preliminary tests, the real bases of judgment for operation will be the age of the patient and the clinical appearance. It will almost invariably turn out that patients under age 50 deserve operation clinically, not just because the tests show favorable responses. The tests at this age show favorable responses because conditions are such the patient deserves operation. Those patients aged between 50 and 60 years frequently deserve operation and those over 60 seldom deserve major surgery for this condition.

Another reason why this is a safe corollary is the variation in the severity of the disease. In very young men the disease runs a violently progressive course. The intensity of its progress abates as the patient becomes older and should the disease make its first appearance in the sixth decade it is apt to be very mild and soon stops after a short active course.

All of this series of nine cases of Buerger's disease operated upon returned to work. None lost an extremity after sympathectomy. All were considerably disabled before operation.

SUMMARY

Sixty patients with conditions requiring temporary or permanent interruption of the sympathetic nerves have been admitted to my private services at Toulo Infirmary and the Baptist Hospital. Twenty-two operations for permanent section of the sympathetic nerves have been done in this group.

Pains influenced by interruption of sympathetic nerve function are varied. They occur in vascular disease with associated vasospasm and may be attributable not only to ischemia, but also directly to the vascular spasm. Vascular changes occur and persist after trauma and pain associated with these may prolong disability unduly. These pains may be surprisingly relieved by paravertebral sympathetic nerve blocks permitting more active physiotherapy for mobilization of joints. Such repeated nerve blocks may often shorten a convalescence dramatically. Cases are presented which illustrate this.

Sympathectomy is indicated in all patients with thrombo-angitis obliterans under age 50. The operation gives many times more increase in vascular reserve in patients with early Buerger's disease than in those affected with a late stage for which it is too frequently reserved.

Raynaud's disease is not a fault of the sympathetic nervous system. Sympathectomy for it is frequently disappointing and eventually may be discarded entirely. These and other phases of the rôle of the sympathetic nervous system in vascular diseases were discussed.

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DISCUSSION—DR MARGARET STANLEY-BROWN, New York City I would like to discuss Doctor Mahorner's paper At the Goldwater Memorial Hospital in New York we see a large group of peripheral vascular cases We have done high saphenous vein ligations on six cases of Buerger's disease, with complete relief of pain and increased exercise tolerance The first case was done more than a year ago We ran a parallel group of arteriosclerotics with no relief of pain

DR JOSEPH E J KING, New York City All of us who were fortunate enough to have had charge of a Neurosurgical Service in the First World War had about the same experience, I cannot go into the details

One of our most serious complications was causalgia In some instances causalgia could be relieved by neurolysis, but in others neurolysis did not relieve the condition Our best results in nerve suture were obtained after suture of the two main branches of the ulnar nerve in the region of the hypothenar eminence, and our worst results were in cases in which both the median and ulnar nerves were sutured, and in which there was gross damage of the major vessels

An average of 65 per cent in return of function would be considered good In some patients we had good results and in others the results were unsatisfactory We found it was best to suture a nerve directly end-to-end without tension, with proper approximation, and with the site of the suture in good tissue In some cases transposition of the nerve was useful We have never seen good results following the long trellis transplant of nerves, probably due to the fact that in the patients in which these transplants were employed, a considerable portion of other soft parts was likewise destroyed

DR JAMES M MASON, Birmingham, Ala Just a word in regard to causalgia I recently saw a lady upon whom an intravenous injection had been attempted, but some of the solution had been placed outside the vessels, and a severe cellulitis had developed in the region of the bend of the elbow Causalgia followed and periarterial sympathectomy had been done without relief The painful symptoms were referred to the distribution of the median nerve With novocain sympathetic block, the pain in the hand was relieved, and alcohol injection was immediately carried out She was entirely free from pain when I had the opportunity of examining her four months later

If I did not misunderstand Doctor Elkin, he does not approve of transvenous arterial suture in dealing with arteriovenous aneurysms, and considers that quadruple ligation and excision should always be carried out In certain instances, transvenous arteriorrhaphy can be employed with advantage It has a distinct place in dealing with arteriovenous aneurysms in the cervical region, where quadruple ligation and excision might be very dangerous

DR HOWARD MAHORNER, New Orleans, La (closing) I was glad to hear Doctor Mason relate his experience with that particular patient, because it is the surprise that, at first, frequently comes with good results from sympathetic nerve block In such cases there is a constant vasospasm and decrease in the temperature of the skin of that area Possibly the spasm of the vessels has to do with pain Leriche was the man who started such therapy in the last war, attempting to relieve these spasms by periarterial sympathectomy There is no experimental proof from the lower animals for the relief of pain by this method It must be done on human beings, and when it is done a few times with the result Doctor Mason described, one is convinced that it is the procedure of choice for such problems

LT COL D C ELKIN, Atlanta, Ga (closing) I am not a neurosurgeon The neurosurgical part of the paper was written by Doctor Woodhall Causalgia is best treated by neurolysis, sympathectomy, or both Quadruple ligation is preferable to other methods, but I agree that, particularly in the neck, it may be dangerous, and transverse closure of the fistula may be the operation of choice

THE SURGICAL TREATMENT OF EXPERIMENTAL COARCTATION (ATRESIA) OF THE AORTA*

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ACCORDING to Biamwell and King,¹ a pathologic narrowing of the aorta in the region of the isthmus, just beyond the origin of the subclavian artery, and varying from a slight degree to complete occlusion, is found in approximately one of every 1,500 autopsies. The mouth of the subclavian artery itself is affected in a small percentage of cases. Involvement of the isthmus itself between the left subclavian artery and the ductus arteriosus is known as the infantile type, while stenosis at or just below the ductus is designated the adult type.

No attempt will be made to review the extensive clinical literature on this subject. The large number of case reports in recent years indicates that the condition is not extremely rare. The chief physical signs consist of evidences of an increase in collateral arterial circulation and an increase in arterial blood pressure in the arms and a decrease in the legs. That coarctation of the aorta is not incompatible with prolonged survival is shown by the observation of Abbott² that the average age of patients at death is 36 years.

Recent experimental interest in coarctation of the aorta has followed the work of Goldblatt, and his associates,³ on the production of hypertension by constricting the renal arteries. The effects of constriction of the aorta have been studied by a number of observers.

Halsted⁴ unsuccessfully attempted complete occlusion by metal bands of the thoracic aorta of dogs. Matas and Allen⁵ reduced greatly the caliber of the thoracic aorta by a method of plication or infolding of its walls. Total occlusion did not result. Reid,⁶ and Pearse⁷ blocked the thoracic aorta by the insertion of foreign bodies into its lumen. Pearse⁸ subsequently reported successful occlusion by the external application of cellophane around the wall of the aorta. By the employment of rubber bands in multiple-stage operations, J. C. Owings⁹ was successful in completely occluding and subsequently dividing the aorta in the thorax. His work emphasized the necessity for bringing about the occlusion gradually. In our preliminary studies we attempted to cause atresia of the aorta by a method similar to that used by Owings, but a good many animals were lost because of hemorrhage. In most instances this occurred at the time that an attempt was being made to tighten the band.

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

The problem considered here may be stated as follows. Since coarctation of the aorta may result in untoward incidents, such as cerebral accidents, it is desirable to find a method to circumvent the stenosis or atresia. It seemed possible that this might be done by performing an anastomosis between one of the large arteries which come off the aorta proximal to the constriction and the side of the aorta distal to the point of stenosis.

METHODS AND RESULTS

A total of 43 experiments was performed on dogs. This number does not include 23 earlier experiments in which an attempt was made to cause atresia of the aorta by the use of rubber bands. Thirty-three of the 43 animals were males. The weights of the dogs ranged from 9.6 to 18 kilograms.

The operative procedures were performed in the following manner. The animals were anesthetized by the intravenous administration of nembutal, 25 mg per Kg of body weight. An intratracheal tube was introduced through the mouth in order that an under positive pressure could be used. With aseptic technique an intercostal incision was made in the fourth interspace on the left. The pleural cavity was entered and a good exposure of the upper part of the thoracic aorta and the left subclavian artery was obtained. The left subclavian artery of the dog arises from the aorta as does that of man. Both carotid arteries and the right subclavian of the dog arise from the innominate artery. The mediastinal pleura overlying the left subclavian artery was incised and the thoracic part of the subclavian was freed from adjacent structures. A bulldog clamp was placed on the subclavian artery at its most proximal part. The artery was then ligated about 5 cm distal to this point and was divided just proximal to the ligature. The aorta immediately proximal and distal to the origin of the left subclavian artery was mobilized sufficiently to allow two rubber-shod clamps to be placed upon it. These clamps were placed about 6 cm apart and the aorta was completely occluded by each of them. The aorta was then divided midway between the two rubber-shod clamps and each end was closed by two rows of sutures of very fine silk. The first row consisted of mattress sutures which were placed about 5 mm from the ends of the divided vessel. The second row was a continuous one which was placed at the points of division of the vessel. The ends of the vessel were anchored together in order that further separation might not occur. The importance of this point has been emphasized by Owings.⁹

A short transverse incision was made into the side of the distal aorta slightly beyond the point at which its end had been closed. The length of this incision was slightly greater than that of the diameter of the subclavian artery. It is important that this incision should be in a transverse direction because the wall of the aorta tears rather easily if the incision is in a longitudinal direction. Furthermore, it is important not to try to clean the aorta of adventitia as is usually done in arterial anastomoses. An end-to-side anastomosis between the proximal end of the subclavian artery and the side

of the aorta was then performed. As in all blood vessel anastomoses, the important point is that intima should be approximated to intima by eversion. A guide-suture was placed at the posteromedial angle. A continuous row of china beaded silk sutures was used for the posterior row. This was tied to a guide-suture which was placed at the posterolateral angle. The anastomosis was completed by an anterior row of continuous sutures of silk. The rubber-shod clamps were removed from the subclavian artery and the aorta. Slight bleeding at the site of the anastomosis could usually be controlled by light pressure for several minutes. In a few instances it was necessary to place an additional suture. A thrill was felt in the aorta distal to the anastomosis following the removal of the clamps. The incision in the chest wall was closed in layers with interrupted sutures. The steps of the operation are shown in Figures 1 and 2.

As stated previously, 43 such operations were performed. None of the animals died during the operation. The time period that the aorta was occluded during the performance of the anastomoses varied from 40 to 65 minutes. The mean arterial pressure (approximate) as measured in the femoral artery by the needle puncture method immediately after completion of the operation ranged from 40 to 130 Mm Hg, the average reading being 85 Mm Hg. The knee jerks were present and usually hyperactive when tested at the completion of the operation.

Only ten of the 43 animals survived the operation for several months or longer. Of the remaining 33 animals, the average length of life was six days. There were six deaths in the first 24 hours. Fifteen of the 33 animals lived for periods ranging from five to 25 days. Included among the causes of death were empyema, distemper, pneumonia, hemorrhage from the site of the anastomosis or the end of the aorta, thrombosis of the anastomotic site, pleural effusion, and paralysis of the posterior part of the body. In eight instances the cause of death was not discovered.

The predominating postoperative complication was paralysis of the posterior part of the body. Paralysis of varying degree occurred in almost half of the cases. In the majority of instances it was complete and was spastic in type. In a few instances there was simply weakness of the posterior extremities. The paralysis was usually noted during the first 24 hours after operation but in several instances it was delayed in onset.

Further description will be limited to the ten cases in which the dogs lived for several months or longer after operation. Nine of these ten animals were males, whereas 33 of the total of 43 were males. The mean femoral arterial pressure at the completion of the operations ranged from 65 to 130 Mm Hg, the average being 89 Mm Hg. The length of time that the circulation was interrupted during the operation varied from 40 to 50 minutes, the average being 44 minutes. These figures differ very little from those observed in the experiments in which survival did not occur. Six of the ten animals showed no paralysis at any time. Two of the dogs had a slight weakness of the posterior extremities which disappeared in a few days. There was a partial per-

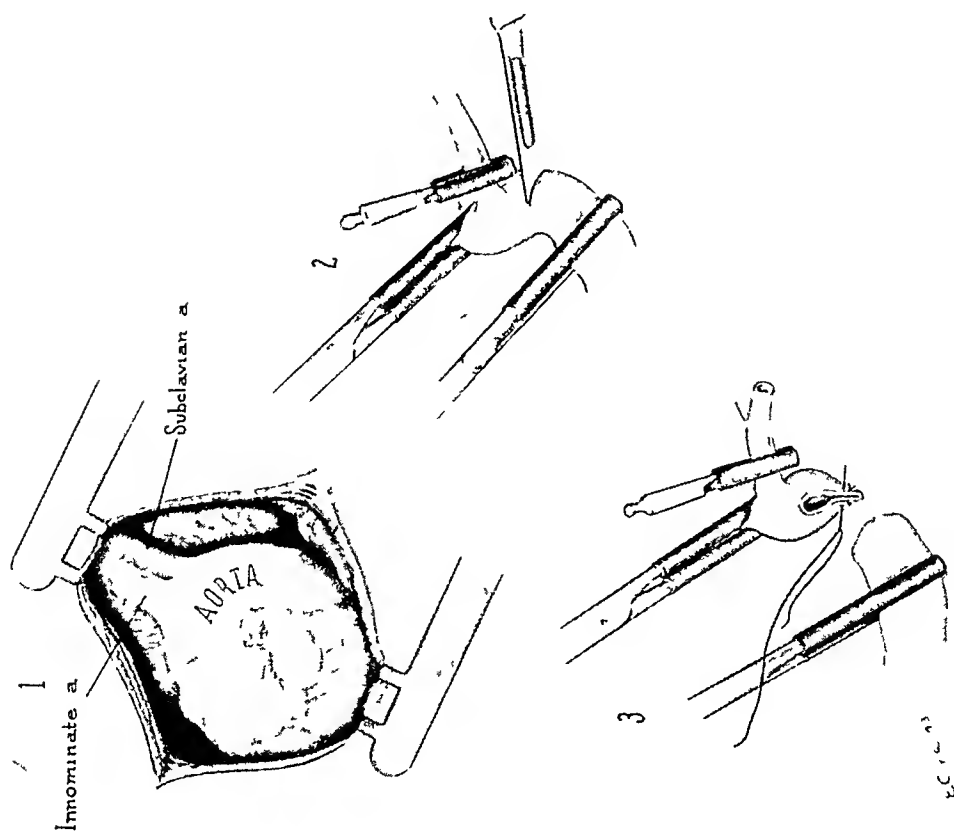


FIG. 1.—Showing the first three steps of the operative procedure (1) Exposure of the aorta and left subclavian artery through an incision in the fourth left interspace, (2) occlusion of the aorta and left subclavian with rubber shod clamps. Division of subclavian artery and aorta, (3) closure of divided ends of aorta

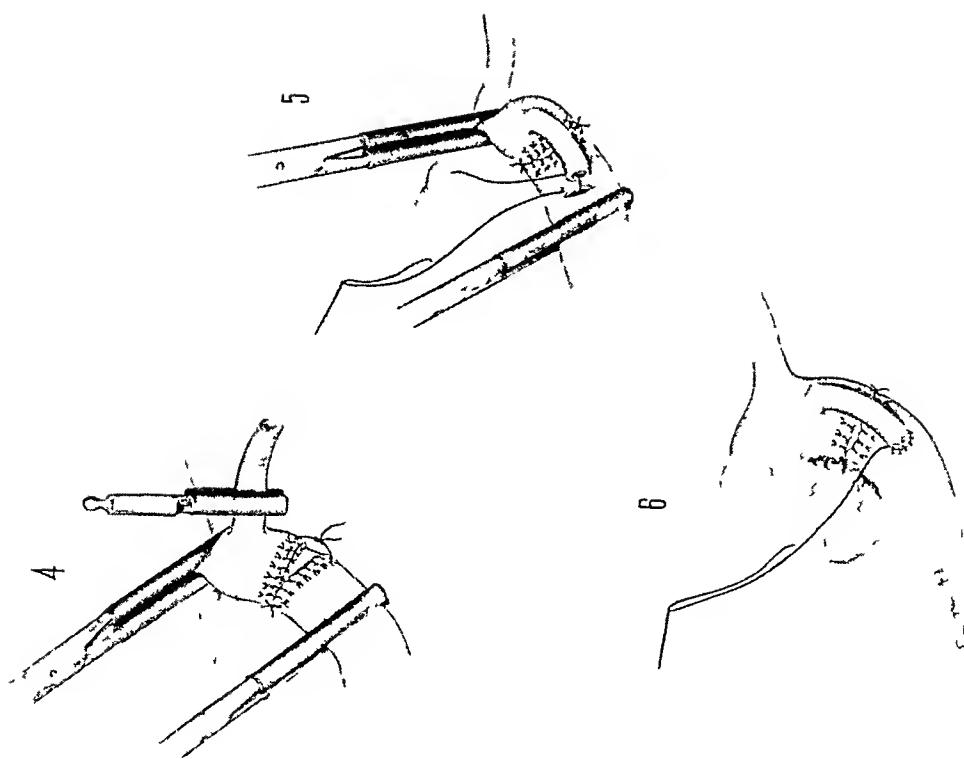


FIG. 2.—Showing completion of operation (4) Closure of ends of divided aorta with two rows of sutures. Ends of vessel anchored in order that separation will not occur, (5) opening made in side of distal end of aorta. Beginning of anastomosis between end of subclavian artery and side of aorta, (6) anastomosis completed

COARCTATION OF AORTA

sistent paralysis of the posterior extremities in one animal and a delayed complete paralysis in the remaining one

The left carotid artery of the animals that survived the operation for an extended period was exposed and was explanted beneath the skin of the neck in order that it might be punctured with a needle that was used for blood pressure determinations. The carotid and femoral arterial pressures were determined from time to time. In each instance the carotid arterial pressure was higher than the femoral but in no case was this difference very great. The figures are given in Table I. The flow through the subclavian artery and through collaterals was sufficient to prevent hypotension in the posterior part of the body.

TABLE I
THE ARTERIAL BLOOD PRESSURE OF ANIMALS WHICH SURVIVED FOR EXTENDED PERIODS
THE OPERATIVE PROCEDURES

Exp No	Femoral B P * Immediately Postopera- tively Mm Hg	Time Since Operation	Carotid B P Mm Hg		Femoral B P Mm Hg		Remarks
			Needle Puncture	Cannula†	Needle Puncture	Cannula†	
31	90	10 months	173		168		Spastic paralysis hind legs Sacrificed
36	80	10 months	175	174/146	145	146/128	Excellent condition Sacrificed
41	65	8 months	155	177/165	120	160/150	Excellent condition Sacrificed
44	130	10 months	150	190/168	135	186/156	Excellent condition Sacrificed
48	90	9 months	160		150		Excellent condition Left sub- clavian artery ligated and divided Died 24 hours later
54	95	4 months	160		138		Died 128 days following operation Cause undetermined Probably pneumonia
56	70	6 1/2 months	185	154/140	165	134/120	Hind legs semispastic Sacrificed
59	85	8 months	165		150		Alive and well
65	90	6 months	135		130		Alive and well
66	90	6 months	150		110		Excellent condition Sacrificed

*Needle puncture

†Mercury manometer no manometer valves Determined under nembutal anesthesia shortly before animals were killed

One of the ten animals died 128 days after the operation. This animal had appeared to be in good condition, and the cause of death was not determined with certainty but was believed to be due to pneumonia. The subclavian-aortic anastomosis was patent. The left chest of one animal was opened nine months after the original operation and the left subclavian artery was doubly ligated and divided. Paralysis of the posterior extremities developed and the animal died 24 hours following operation. This experience suggests that the transplanted subclavian artery had been effective in conveying blood to the posterior part of the body. Six of the remaining eight animals were sacrificed at intervals ranging from six to ten months following the performance of the subclavian-aortic anastomosis. Hill's radiopaque mass was injected into the arterial system and roentgenograms were made immediately after death. Typical roentgenograms are shown in Figures 3 and 4. The anastomosis was patent in all instances. The subclavian artery appeared

to be somewhat dilated. There was some increase in the size of collateral pathways but this was not pronounced. The roentgenograms shown in Figures 3 and 4 may be contrasted with that in Figure 5, which is reproduced from the paper by Doctor Owings. It will be recalled that he produced gradual occlusion of the aorta, and the tremendous increase in the collateral arterial



FIG 3—Reproduction of roentgenogram which was made following the injection of Hill's mass. The arrow points to the left subclavian artery, which was used for anastomosis to the side of the aorta distal to the point of its division and closure. The collateral arterial pathways are only moderately enlarged.

pathways is shown in Figure 5. Photographs of two of our gross specimens are shown in Figures 6 and 7. Microscopic sections of liver and kidney did not reveal abnormalities. Photomicrographs of the vessels at the site of the anastomosis are shown in Figures 8 and 9.

Two of the animals are alive and appear to be entirely normal. They will be observed for an extended period.

COARCTATION OF AORTA

DISCUSSION

It had been demonstrated previously that dogs will not survive an acute one-stage occlusion of the thoracic aorta. It was found¹⁰ that the survival period following one-stage complete occlusion of the thoracic aorta is usually only about three hours. Erlanger and Gasser¹¹ conclude that the fall of blood



FIG. 4.—Roentgenogram following the injection of Hill's mass. Arrow points to left subclavian artery.

pressure and early death after occlusion of the aorta are due to a reduction in the effective volume of blood. The fact that some of the animals in the present study survived complete division and closure of the aorta shows that the subclavian artery was effective in conducting blood to the posterior part

of the body. The fact that there was not hypotension in the posterior part of the body and hypertension elsewhere also suggests that the blood flow was adequate. The absence of a decided increase in the size of collateral pathways (as demonstrated by Owings in simple progressive occlusion) indicates that



FIG 5—Roentgenogram reproduced by courtesy of Dr J C Owings (Annals of Surgery, 115, 596, 1942). The extensive collateral circulation which develops as a result of multiple stage occlusion and division of the thoracic aorta is demonstrated. The collateral circulation is much less extensive in our studies (Figures 3 and 4) in which a subclavian aortic anastomosis was performed.

in our studies a large part of the blood supply to the posterior part of the body must have passed through the subclavian artery. The death of one animal following subsequent operative occlusion of the subclavian-aortic anastomosis is also evidence in favor of this viewpoint. Our studies show that the femoral arterial pressure at the conclusion of the operation does not allow one to predict with any degree of certainty the chances of survival of

the animal. Some of the animals with the highest femoral arterial pressures died within a relatively short time after operation.

In only five of 43 experiments was the subclavian artery or the anastomosis blocked by a thrombus. In two of these there was a clot in the proximal end of the divided aorta which extended beyond and blocked the mouth of the



FIG 6

FIG 6—Showing a photograph of the thoracic aorta which was removed 10 months after we had divided the aorta and had performed an anastomosis between the subclavian artery and the side of the distal end of aorta. (1) Innominate artery arising from the arch, (2) left subclavian artery, (3) proximal end of divided aorta, and (4) distal end of divided aorta.



FIG 7

FIG 7—Showing a specimen of the aorta which was opened in a longitudinal direction. (1) Innominate artery, (2) left subclavian artery which is considerably larger than at the time that the anastomosis was made, (3) proximal end of divided aorta, and (4) distal end of divided aorta.

subclavian artery. Thus, the anastomosis appears to be feasible from a technical standpoint.

The most disturbing factor was the paralysis which resulted in many instances. The cause for this has not been determined and the subject merits further study. It seems most likely that the paralysis results from an interference with the blood supply to the spinal cord. In a description of the results of complete and incomplete occlusion of the abdominal and thoracic

aorta by metal bands. Doctor Halsted⁴ states "The study of the spinal cord was entrusted to Mr P K Gilman (now Doctor Gilman, and a member of

FIG 8

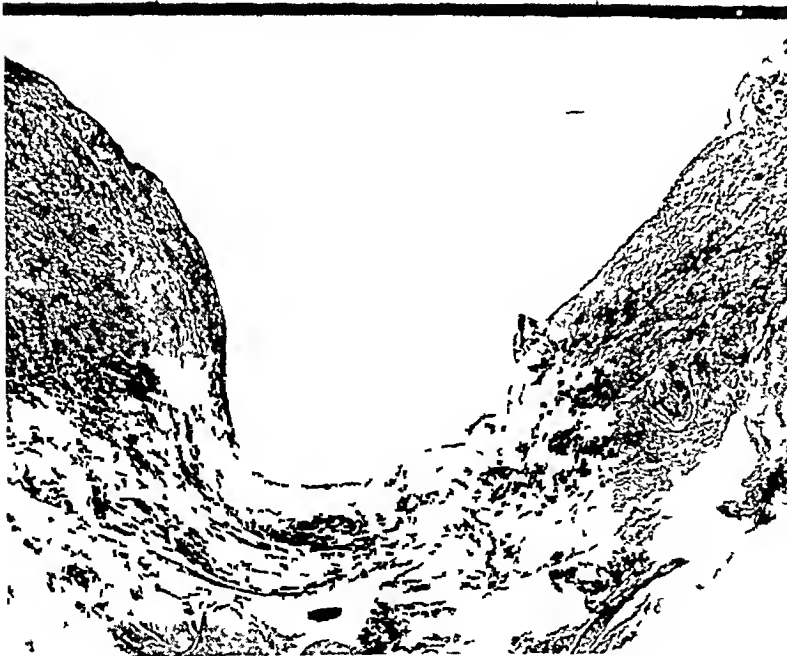
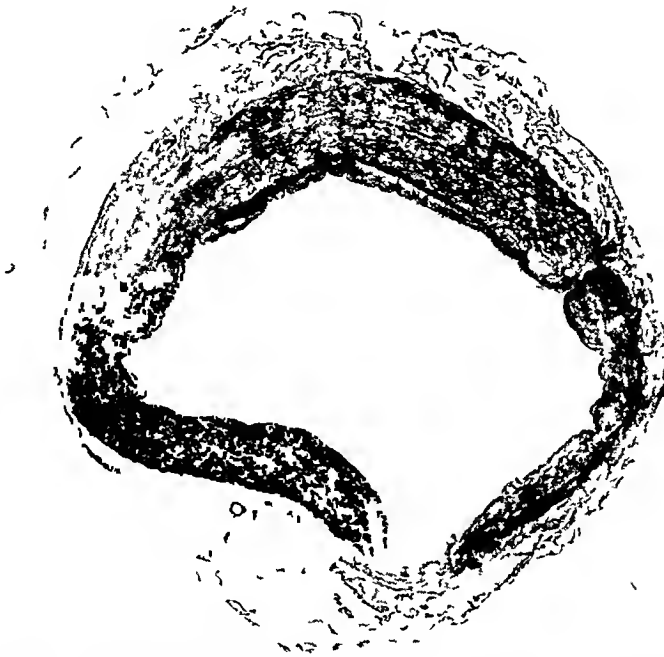


FIG 9

FIG 8—Photomicrograph of site of anastomosis of end of subclavian artery to side of aorta (x8)

FIG 9—Photomicrograph of site of anastomosis (x35) Several silk sutures are visible

my staff), whose trained eye discovered in a number of cases, about three months after operation, a deposit of extradural fat about the cord below the

site of the aortic band. In three cases the production of fat was so great that it filled, seemingly under considerable tension, the vertebral canal." This finding was not encountered in our studies. Furthermore, the onset of paralysis was so rapid in some of our animals that it could not be explained on this basis. In two control experiments the thoracic aorta and the left subclavian artery were occluded for 50 minutes and then released, without division and anastomosis, and paralysis did not occur.

There would be some obvious objections to the use of the subclavian artery in man if the operative procedure described here, or a modification of it, was to be used. In the first place, the subclavian artery is the most important vessel in supplying blood to collateral pathways around the point of stenosis or atresia of the aorta. Division of this vessel might interfere considerably with this blood supply. In the second place, division and rotation of the subclavian artery might interfere too greatly with the circulation of the arm. It would seem that the left common carotid artery is a better vessel to use. It was not used extensively in the present experiments because it arises in the dog from the innominate artery rather than from the aorta and because its lumen is smaller than that of the subclavian. The left common carotid artery was anastomosed to the aorta in several dogs, but the femoral pressure immediately afterward was found to be less than 50 mm Hg and death occurred. The common carotid artery presents the advantage over the subclavian of having few branches. Since many collateral pathways are already existent in the patient with coarctation, it is our impression that the additional quantity of blood supplied by the carotid would be sufficient to improve considerably the circulation of the lower part of the body.

Although this operation has not been attempted in man, it would appear that the enlarged collateral vessels which enter the aorta below the point of the stenosis in the patient with coarctation would make it difficult to obtain a dry field for the performance of the anastomosis. On the other hand, it would appear that the patient with a chronic partial occlusion of the aorta would tolerate a temporary complete occlusion better than the normal dog in which there has been no stimulus to the formation of collateral arterial pathways. In any case, this procedure, or a modification of it, should be considered only in those cases of coarctation in which the outlook is very grave since many patients with coarctation of the aorta have a fairly long life expectancy.

SUMMARY

These experiments were undertaken with the idea of devising a means for the surgical treatment of coarctation of the aorta. At a one-stage operation the thoracic aorta was divided, the two ends were closed, and the proximal end of the divided left subclavian artery was anastomosed to the side of the aorta beyond the point of its division. Some of the animals survived this procedure, and there was evidence of adequate blood flow to the posterior part of the body. The possible clinical application of these studies is discussed.

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LIGATION OF THE ABDOMINAL AORTA FOR ANEURYSM⁺

COMPLICATED BY RUPTURE INTO THE RETROPERITONEAL SPACE

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THE TREATMENT OF ANEURYSM of the abdominal aorta by ligation was thoroughly reviewed in 1940 by Biggel, Elkin, and Matas. There have been no reports of this procedure subsequent to that date. These authors found that since the original report of Cooper, in 1817, to their own, in 1940, there had been only 30 reports of ligation of the abdominal aorta for aneurysm of the aorta or of the common iliac at its origin. Only seven of these operations could be regarded as in any degree successful. Elkin included four instances in which the aorta had been ligated for trauma or tumor and only one of these patients lived for any length of time afterwards.

Bigger claimed that many of the problems connected with aortic aneurysm could be solved only by observation on patients thus afflicted. Consequently, it seemed important to record the results of ligation of the abdominal aorta in a patient with aortic aneurysm and rupture into the left retroperitoneal lumbar space.

Case Report—Hosp No 581 J G, male, age 52, was admitted to the Strong Memorial Hospital January 10, 1942. He was feeling about as usual until the previous day. During the morning he began to have dull pain in the left flank. He ate lunch downtown and the pain became severe enough to make him go home to lie down. At 2:30 P.M., he had a sudden agonizing pain in the left lower quadrant. When his physician saw him ten minutes later, he was in obvious shock, with a greenish pallor, cold sweating, and a small thready pulse. He was groaning with pain and afraid to move lest his pain become worse. The pain did not radiate. The whole left side of his abdomen was tender. There was slight tenderness over the left kidney region. The muscles just above the pelvic brim on the left were held slightly tensed but the right side of the abdomen had neither muscle spasm nor tenderness. It required two $\frac{1}{2}$ gram doses of morphine to get relief during the next 30 minutes. In $1\frac{1}{2}$ hours, his shock was under control, his pulse was much stronger and he could be moved without much pain. He remained free of pain till about 12 hours later. Then (1:30 A.M.) the pain returned to the same region with lessened intensity. Morphine gr $\frac{1}{2}$ and atropine gr $\frac{1}{150}$ gave relief so that he slept for $1\frac{1}{2}$ hours. At 3:00 A.M. he had more pain, and more heavy drugging which gave him only about four hours relief. At 8:00 A.M. he was brought into the hospital by ambulance. He had not voided for 18 hours.

In the past, he had had severe episodes of migraine, due in part to food sensitivities. There were also infrequent asthmatic attacks, especially with respiratory

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infections. He had been away from work for about one year (till six months ago) because of marked depression. He had had his appendix removed 23 years previously. He had had a slow tremor of the hands for years.

Physical Examination—The patient was pale. There was tenderness in the left lower quadrant and resistance to deep palpation. A definite, exquisitely tender mass could be felt in the left lower abdomen. Ballottement was not attempted because of the pain. There was only slight costovertebral tenderness. His temperature was subnormal, pulse 100, respirations normal. Blood pressure 120/70.



FIG 1—An intravenous pyelogram shows slight displacement of the left ureter and a normal kidney pelvis. The calcifications to the right of the fourth lumbar vertebra and in front of the sacrum were considered as possibly arteriosclerotic.

Laboratory Data Red blood count 3,200,000, hemoglobin 8.5 Gm, white blood count 13,800. The urine showed no blood and a good function as judged by the phenolsulfonphthalein test. The stools were not remarkable. The nonprotein nitrogen was 61 mg per cent, creatinine 2.1 mg per cent, total proteins 5.7 per cent, phosphorus 8.1, and phosphatase 3.7 Bodansky units. The blood Wassermann was negative.

He was a diagnostic problem at this time. Ureteral stone was suggested but ruled out by the negative urinary examination and the negative intravenous pyelograms (Fig 1). Other possibilities were retroperitoneal tumor and dissecting aneurysm. These were thought of because of some calcifications seen in all films both to the right of the spine at the level of the iliac crest, and across the sacrum from right to left, as well as a large soft-part shadow in the left lumbar region.

On bed rest he appeared to improve. During the first days in the hospital he had the sensation of something pressing in his abdomen. He showed some dullness over the lower half of the left chest with diminished breath sounds and diminished whispered voice. The blood pressure in both arms was 120/78. The tenderness gradually subsided.

LIGATION OF ABDOMINAL AORTA

during the first week. It was possible to feel a smooth mass which extended toward the midline but had no definite edge. The left femoral artery seemed to have a smaller excursion than the right.

Blood pressure, right thigh 130/80, left 140/82 (not entirely satisfactory). By the end of the first week, there was an easily distinguishable pulsation over the left lower quadrant. This was synchronous with the aortic pulsation. It was not possible to make out expansile pulsation in the mass. On the twelfth day after admission there

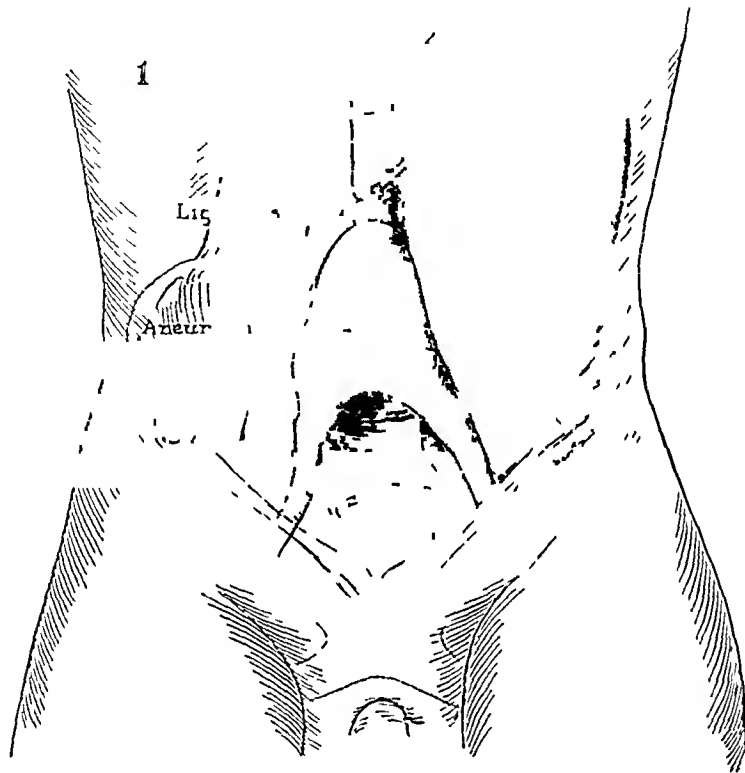


FIG 2—The condition following operation showing the blood extravasation into the left lumbar retroperitoneal space. The double ligation of the aorta with cotton tapes below the origin of the inferior mesenteric artery is shown.

was noted a definite swelling of the left thigh with slight pitting edema at the ankle. There were no signs of thrombosis, such as Homan's sign, tenderness on calf pressure or tenderness in the popliteal space. He began to sit up on the edge of the bed about this time. Things seemed to be progressing nicely. He was up in a chair for a short time on the fourteenth day after admission.

On the morning of the next day, he began to have aching in the left thigh, gradually extending to the leg as well. The entire limb was more swollen. There was no tenderness except in the deep femoral triangle. The peripheral arterial pulsations were easily made out.

A venogram was made because of a slowly rising pulse rate. It showed presumable thrombosis in the left femoral vein. Exploration of the abdomen was done in the hope that a diagnosis of the mass could be secured as well as ligation of the iliac vessels. There was a large mass with expansive pulsations in the left iliac fossa. The aorta above this contained several "egg-shell" plaques. There was a large area of blood clot outside the left iliac aneurysm extending as far upward retroperitoneally as the left kidney. Closure was made, as this problem required discussion with the patient and his family.

Lumbar sympathetic block was done four days later, without untoward effects. No definite improvement was noted.

On January 29, 1942, the abdominal wound was reopened and two tape ligatures, about one-half inch apart, were placed about the terminal aorta just below the inferior

mesenteric artery (Fig 2) They were tied so that a faint pulsation could still be felt in the dilated abdominal aortic aneurysm The expansile pulsation disappeared and the area became soft. The operation caused little disturbance in the patient's general condition On recovery from the ether anesthesia, he had severe pain in his left leg This was relieved by lumbar block in the second interspace There was also abdominal and back pain, and later, pain in the left hip region The next morning, the left upper leg became mottled purplish-red Blisters appeared over the lower part of this limb The right leg seemed normal but the left was quite swollen Two days after operation,

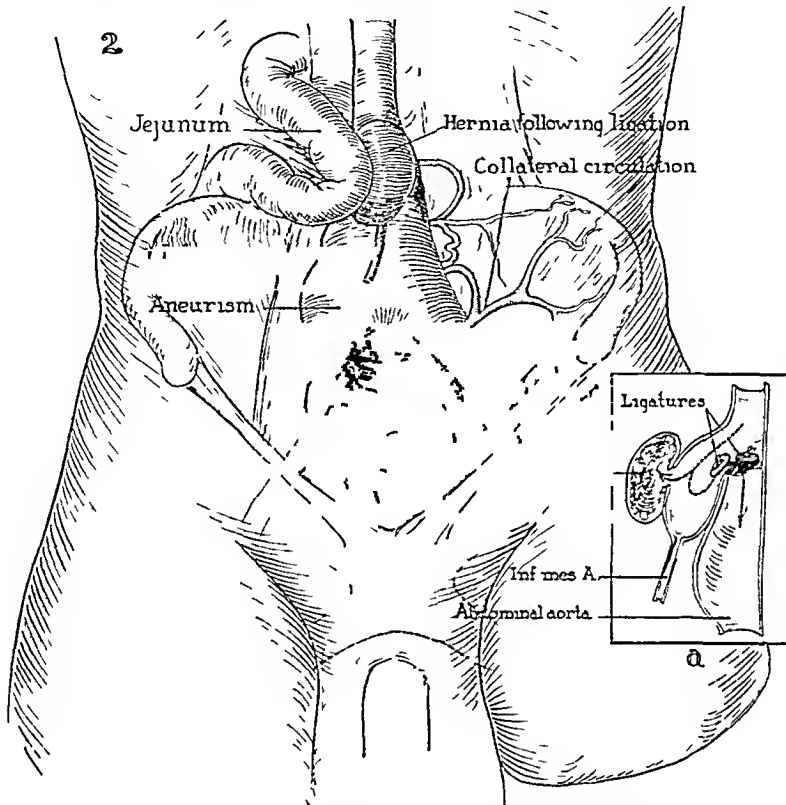


FIG 3—The condition found at postmortem examination The collateral circulation was worked out by dissection and studies of the injected vessels in roentgenograms

he moved his right leg and foot without trouble There was a good capillary return on pressure over the skin The circulation seemed fair but no pulsations could be recorded in the peripheral vessels Sensation was not present The toes of the left foot began to shrivel On February 1, 1942, tingling and returning sensation was noted in the right leg The left leg began to show a line of demarcation at the midthigh level A good femoral pulse could be palpated on the right on February 4

He began to have evidence of absorption from his gangrenous leg by February 8 A high thigh amputation was performed on February 9 under sodium pentothal anesthesia There was very little bleeding The main arteries and veins were completely occluded by clots All muscular tissue was excised until free bleeding was obtained Many of the muscles were necrotic all the way to their attachments at the pelvis The wound was blown full of sulfadiazine and left open except for one suture in the center of the stump which brought the skin together there

The stump healed slowly The wound was sluggish and reactionless It oozed a thin serous material and became covered with dirty sloughs *B subtilis* became established in it in spite of every precaution Sulfadiazine was used at first, then azochloramide and normal saline By the first of March, granulations were healthy appearing, the

stump was shrinking in size, and progressing favorably. He began to complain of a phantom limb. He noted pain in it "as if the heel were held in a vise." The pain started usually at 6:30 P.M. and lasted fully two hours. Another time when the phantom was especially prominent was just after he awakened. The limb seemed of normal length. The toes were not in an unusual position. The consciousness of the limb disappeared as he tended to move about. By March 11, the epithelium was growing across the stump end. It was healed except for the inner side. He was walking about his room on crutches. He felt no pain in the stump now but he was conscious of the phantom at times. Pain in this was now mostly confined to the foot though he had a

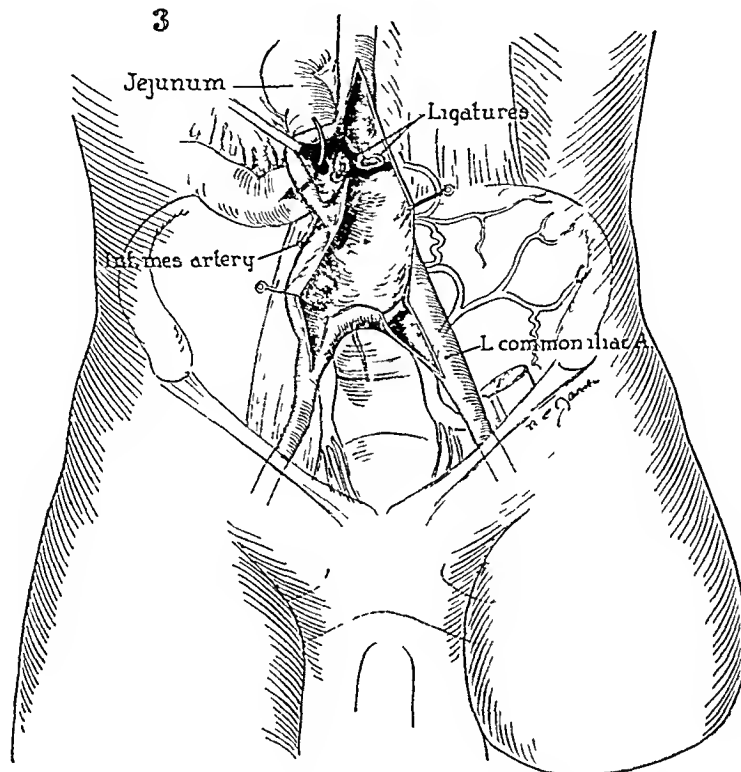


FIG. 4.—The specimen opened to show the tapes and the fistula to the jejunum from the newly formed aneurysm of the aorta.

sensation of constriction in the calf now and then. The foot seemed bent at an angle. On March 17, he had severe pain in the phantom limb. The pain shot through his foot "like a red hot iron from heel to toe." There was a sensation through the instep "as if it is being pushed together,—a poor description but it is hard to say exactly what it is like,—a squeezing sensation." There had been also a flickering sensation down the back of his thigh "sort of like a fork of lightning." He was conscious of no sensation between the stump and the foot. The limb had shortened to the level of the knee. The foot was pointed inward. The toes seemed to be bent upward. The recent bad weather caused accentuation of all these complaints. Codene gave relief. A paravertebral block gave relief for about one-half hour. The stump slowly progressed toward healing. The phantom was shrinking as well so that by March 24 it was above the knee level. There were occasional stabs of severe pain which caused him to wince and even to cry in agony. These pains began to space out and were less intense during the last three days. On April 2, three small pinch grafts were taken from the skin of the lateral stump under local procaine anesthesia and applied to the remaining granulating surface. While the grafts were being taken, he claimed that the pain in the phantom foot was increased although he felt nothing at all locally. He was discharged on April 10, 1942, with the stump practically healed. He was getting about on crutches. The phantom limb still "gave him hell for one to two hours a day."

At home he gained in weight and strength. He was able "to walk a mile on crutches." His appetite and digestion were good. Stools were normal. The phantom leg still gave trouble. It had shrunk in size and occupied a position with the knee flexed and the foot opposed to the right thigh. There was continuous prickling in the foot and frequent attacks of "red hot" pain in the dorsum of the foot and in the skin. When he first went home he had two episodes of pain daily. One came in the late afternoon and the other in the evening. Gradually the afternoon attack came earlier



FIG 5—Injection of the artery with a radiopaque liquid latex showed an extension into the jejunum which was explained by later dissection

and earlier in the day till it finally came on just after breakfast. Walking and exercise caused the morning attack to lessen but the evening episodes became worse. Deep pressure on the stump produced pain only in the stump. But light stroking of the skin in the posterior flap produced severe pain and burning referred to the toe area of the phantom foot. The sensitive areas were especially marked over the medial third of the posterior flap of the stump with a less sensitive area over the outer third. He got relief on "Alba D"—a morphine replacing substitute drug. He had returned to work, taking part in committee and departmental duties. He carried on his dictation and correspondence as he had previously.

He was again admitted to the hospital, and a spinal anesthesia was done. Anesthesia was obtained to level of D9. Motor function of the right lower leg was lost for ten

minutes All painful sensations were absent in the left stump but he retained sensation in the phantom limb—though it was not a disagreeable type of sensation Stroking of the trigger areas in the skin was not felt and no psychic disturbance was elicited It was decided that section of the peripheral nerve trunks might help in reducing his pain Accordingly, under avertin and nitrous oxide-oxygen anesthesia, the great and lesser sciatic nerve stumps were divided The amputation stump had very little blood supply

After he left the hospital, the phantom leg pain was reduced at least 90 per cent Most of the time pain was entirely absent The phantom itself continued to be present It gradually became smaller, with the leg flexed on the thigh and the heel drawn up into the crotch He had the sensation that he could straighten out the leg by great voluntary effort but it would snap back promptly into the flexed position He was rarely able to forget its existence

He went into a depression fearing that he would never be able to undertake his previous occupation When he did his scholastic work, he found it hard to concentrate He made frequent errors in mathematics which distressed him as he had always been accurate He began to take relatively large doses of bromochloral and phenobarbital to get relief from insomnia and worry After July 1, he was found to have a bromide level of 210 mg per cent in the blood Bromochloral was stopped Seconal and increased phenobarbital was substituted The mental confusion cleared up and the blood bromide level dropped to 75 mg per cent in a week Large doses of sodium chloride had been used but in spite of this the bromide retention had gone on

Early in July he had an attack of severe diffuse, lower abdominal pain The pain did not localize It was accompanied by sweating, pallor, a drop in blood pressure from 110 to 100, and a sensation of fright Two doses of $\frac{1}{4}$ grain morphine gave relief In 24 hours, he seemed normal again Two similar attacks came at two-week intervals with rapid relief following morphine Between attacks he walked about with crutches up to a mile a day He drove his car to his office daily where he took care of his correspondence One of the attacks came a couple of hours after he had climbed a flight of stairs

His depression deepened Reassurance was of value for only a day or two He was convinced that he could never carry on his duties On two occasions he stated that he would end his life if the means were at hand

While taking a walk on August 14, he had a mild attack of abdominal pain It persisted in varying intensities up to the time of his death There was no let-up in it even under heavy sedation He complained of a "peculiar sensation in the head" By August 16, the pain had become very severe, accompanied by pallor, sweating, and a rapid, weak, irregular pulse He was quite weak and unable to eat solid food On August 18 he passed by rectum a large amount of fluid containing both dark and bright red blood During the day, he had two more similar movements He was extremely pale and very weak by nighttime His pulse increased to 130, his blood pressure dropped to 90/50 There were several attacks of hiccoughs lasting as long as one-half hour He appeared to be on the point of death But on August 19, he sat up on the side of



FIG 6—The circulation in the right thigh was in excellent condition

his bed and washed himself. He was quite confused mentally during the next day or two. On August 22, there were two more blood-containing stools. Hiccoughing continued, relieved somewhat by various sedatives. He lived on liquids mainly. He went on in this manner until 11 00 P.M. on August 28 when he quietly expired. This followed another painful episode associated with sweating, pallor and falling pressure. During all these attacks of abdominal pain, there was no spasm of the abdominal muscles. Even fairly deep pressure did not alter the pain. The abdominal aorta could be palpated easily. It appeared to be wider than normal especially at the level of the umbilicus. There was also an enlargement which was taken to be the right iliac artery.



FIG 7 —The circulation in the right leg and foot was adequate

Autopsy—The aorta had formed a new aneurysm above the point of ligature. This sacculatation prolapsed over the area which had been tied off. The tapes had cut through the vessel wall and had apparently eroded through the new aneurysmal sac into the small intestine, just beyond the duodenojejunal junction. The jejunum at this point had become attached to the aneurysmal sac. There had been massive hemorrhage into the small intestine. The old aneurysm was filled with a blood clot. There was thrombosis with organization in the left common iliac artery and in the old abdominal aortic aneurysm, the left external iliac artery and the left proximal hypogastric artery. The circulation to the stump had been carried by collateral enlargements of the lumbar and sacrospinal arteries and the distal left hypogastric artery. The right iliac arteries were intact and functioning well.

In addition, there was generalized and coronary arteriosclerosis. There were focal myocardial scars with cardiac hypertrophy and dilatation. Chronic pancreatitis and

chronic cholecystitis with cholelithiasis and mild cholangitis were present also. The kidneys had arteriosclerotic scars. There was an old focal encephalomalacia (Figs 3 and 4).

This patient presented a problem for diagnosis on entry. His severe pain and anuria pointed to a urologic cause but examination did not seem to bear it out. Aneurysms of the abdominal aorta frequently have been regarded as urologic diseases, such as renal lithiasis, renal tumor, perirenal hemorrhage from trauma, hydronephrosis, or perinephric abscess. Uhle has presented an interesting review of this subject. It was possible to feel a mass in the left lower abdomen but pulsation in it was not elicited in the first days. There



FIG 8—The collateral circulation across the lumbar and sacral spinal arteries and through the distal hypogastric and its branches is beautifully demonstrated

were no differences in the femoral pulsations noted. A retroperitoneal tumor was strongly considered. The roentgenogram showed some calcifications which were thought to be in the aorta or iliac vessels and suggested aneurysm to some members of the Department of Radiology. It was only after a progression of the symptoms and signs had led to an exploration that the diagnosis was definitely established.

The problem of controlling aneurysms of the abdominal aorta has not been solved as yet. When the aneurysm has had a traumatic etiology and the patient has youth and elastic vessels, operations such as those performed by Bigger have a happy outcome. But in individuals with aneurysms on an arteriosclerotic basis, with other calcified areas in the vessels, the chances for cure are much less favorable. Bigger emphasizes that aortic occlusion is unjustifiable in patients with extensive diffuse calcifications of the aorta.

Elkin claims that an efficient collateral circulation rarely exists about an aortic aneurysm. Consequently, occlusion should be partial only and not complete. Otherwise gangrene of the extremities will result. In case the collateral circulation has developed well, recurrence of the aneurysm in a short time is likely. Ligation of the aorta above the region of celiac or renal vessels cannot be tolerated as it jeopardizes the vitality of the intestines and kidneys. Ligation in continuity of a large artery will almost invariably be followed by gradual cutting through of the ligatures and either hemorrhage or reestablishment of the channel. If the proper time could be estimated, excision of the involved artery would seem to be a logical step unless an endo-aneurysmorrhaphy can be done.

It would seem that the method for occluding a large artery would be a relatively simple problem. But such is not the case. It has occupied the best thoughts of some of our most distinguished surgeons and still has not been completely solved. Pearse has reviewed the methods used and claims that all methods which depend upon external compression are dangerous. He has produced occlusion in animals by a spring screwed into the lumen of the aorta. This caused a gradual occlusion by thrombosis. It has not been found possible to easily insert such a spring in a deep wound. Extravascular occlusion by a sheet of cellophane has been successful in some animals but has been associated with rupture of the aorta in others. This method has promise and should be investigated more completely. At the time of Pearse's report the result of using a cellophane sheet was considered unpredictable. It has been successfully used since in the human by Harrison and Chandy to occlude a subclavian aneurysm. The method of occlusion of the aorta by rubber bands as advocated by Owings might also be considered. It has required multiple applications in order to get a successful outcome. This would be against its use for human cases.

Of all the external ligature material used to the present cotton tape seemed to be the most applicable. In Matas' patient a brilliant result was reported. The cotton tape was incorporated into the wall of the vessel and did not cut through. In four of the seven successful ligations it was the material used. And yet in our case, used according to the published methods, it has followed the rule and cut through the vessel walls producing a fatal outcome.

Our patient was of interest in the postoperative period because of the ensuing gangrene requiring amputation of the left thigh. The phantom limb from which he suffered was of extraordinary interest. Contrary to our usual experience we were able to define a trigger zone in his case. And by a simple redivision of the nerve trunks of the sciatic and lesser sciatic he was to a large extent relieved of his symptoms.

The postmortem studies of the collateral circulation were carried out by injection of a radiopaque liquid latex mass. This enabled us to obtain radiographs of the circulation and to dissect the vessels out intact afterwards. It was made possible through researches on this phase by Tobin. He showed a beautiful demonstration of the important collateral anastomoses through

the two lower lumbar and ilio-lumbar arteries to the left internal iliac (hypo-gastric) artery. This latter artery had slightly enlarged channels but its branches were normal in their distribution. The middle sacral and left lateral sacral arteries were filled with injection material and were easily dissected out. The left common iliac and the left external iliac arteries were completely occluded. No evidence of a previous rupture of the left common iliac artery could be demonstrated. The openings of the lumbar arteries into the aneurysmal sac were patent. All the arteries of the right pelvis and right extremity were filled with the latex material and appeared to be normal (Figs 5, 6, 7, and 8).

Rupture of abdominal aortic aneurysm into the gastro-intestinal tract is a rare complication according to Smith. He found that there were, at most, probably less than 25 cases reported in addition to his own observation. In the present instance, the etiologic factor was that of a foreign body which would place this case in a different category.

We were much indebted to Dr Stearns Bullen, Dr Richard Jaenke and Dr W W Scott, of the clinical branches, and to Dr Charles Tobin of the Anatomical Department for his assistance in the vascular studies and dissections.

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THE TECHNICAL SIMPLICITY OF THE MATAS ENDO- ANEURYSMORRHAPHY*

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In Its Simplicity Lies Its Virtue

IN 1903, Dr Rudolph Matas¹ gave to the surgical world an operative procedure designed for the surgical cure of aneurysm of the major peripheral arteries. Since his first reports on cases of arterial aneurysms cured by this method (aneurysmorrhaphy), there have been yearly reports on the successful cure of arterial aneurysms by the Matas method from surgeons throughout the world.

Although the simplicity of the technic of endo-aneurysmorrhaphy has been repeatedly discussed both by Doctor Matas,¹⁻⁴ and the author,⁵⁻¹⁰ through the medium of journals and surgical meetings, it is unfortunate that its simplicity and applicability has not been thoroughly appreciated. A majority of surgeons think of this operation as being of a most formidable nature and resort to either the Japanese or English method of ligation and complete excision of the sac, or to a remote surgical procedure used by John Hunter in 1785.

The lack of familiarity with the over-all technical procedures of endo-aneurysmorrhaphy and its application, which not only involves the operative but the preoperative preparation and postoperative care as well, is due to two factors. First, the fear of uncontrollable hemorrhage during the operative procedure, and second, the inexperience of the surgeon in vascular surgery. The fear of uncontrollable hemorrhage during operations upon the heart and major arteries is dependent upon the dramatic descriptions of operations upon the heart and great vessels. It is common for the authors to dramatize the hissing noise and foaming blood in stab wounds of the heart, and the spurting stream of "whistling and gurgling" blood escaping from a major artery or aneurysm during operative interference. Then again, it has been almost a law that one, and only one, surgeon who has had his baptism in the blood of vascular surgery is allowed the honor and privilege to operate upon all the cases of injury or disease of the vascular tree. This unfortunate state of affairs has resulted in the training of very few vascular surgeons. It is the duty of all vascular surgeons to thoroughly train their residents in vascular surgery to the degree where they should handle all of the emergency injuries to the heart and major arteries. I have knowledge of some cases of stab wounds of the heart dying while waiting for the heart surgeon (the only heart surgeon!) to arrive and dramatically suture the bleeding heart. If, in the

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past, we had taught the residents all the fundamentals, both physiologic and pathologic, pertaining to surgery of the vascular tree, we would have sufficient vascular surgeons who are now so badly needed at the battle fronts. I believe that many limbs could be saved today on the battle fronts if the surgeons who are doing the surgery had been thoroughly indoctrinated in all phases of vascular surgery while serving their residencies or apprenticeship. Therefore, the author requests that a course in vascular surgery be part of a surgical resident's training. This training should be conducted upon the experimental animal—fresh and preserved cadavers—and clinical application under a trained vascular surgeon, not one who limits himself to vascular surgery, but a general surgeon who has specialized in this most interesting and neglected field.

The operation of endo-aneurysmorrhaphy not only entails a thorough knowledge of the technic, but a familiarity with the pathologic physiology of aneurysms, both local and systemic, the absolute control of all bleeding during the operation, collateral circulation, methods of testing the collaterals and procedures used to develop a negligible and sluggish collateral circulation, and the preoperative and postoperative treatment.¹⁻¹⁰

Doctor Matas divided his endo-aneurysmorrhaphy into the types (a) Restorative, (b) reconstructive, and (c) obliterative.² The restorative is only applicable to the true saccular type of aneurysm. This type of aneurysm is produced mainly by trauma—stab wounds and gunshot wounds in which there has been only a small opening made in the artery—or in cases where there has been a minimum loss of the arterial wall. This type of aneurysm represents the minority group. This operation is one in which the lumen of the artery can be restored because there has been no loss of any part of the arterial wall. The restorative is not applicable to any other type or form of arterial aneurysm. Grave mistakes are made when adopting this procedure for aneurysms not of the pure saccular type.

The reconstructive operation was designed for the fusiform type of aneurysm. The technic consisted of forming a new segment of artery out of the walls of the aneurysmal sac. It was observed that in the majority of cases the newly formed arterial segment thrombosed very rapidly post-operatively. Therefore, this procedure was discarded in favor of the obliterative technic, which is recommended for all forms of arterial aneurysms except the pure saccular type. The obliterative endo-aneurysmorrhaphy consists of opening the aneurysmal sac with intrasaccular closure of all arterial openings and complete obliteration of the sac. Therefore, the obliterative type of endo-aneurysmorrhaphy is the procedure of choice in all arterial aneurysms both traumatic and organic of the peripheral arteries, with exceptions as noted above.

There is a group of arterial aneurysms in which the methods described above are not applicable. They are as follows: Common carotid group, subclavian group, aorta group, iliac group, aneurysms of the innominate artery, splenic artery, renal artery, common femoral artery, gluteal artery,

and the intracranial group. The procedure of choice in the above group is that of Anel, *i e*, proximal polar ligation of the main artery entering into the formation of the aneurysm. In the low carotid, subclavian and innominate groups, the author recommends the transpleural, transthoracic approach of Touroff.¹³ The author¹⁰ has used this method in one case with gratifying results.

In the above descriptions of the various technical procedures there is a single factor common to all, that is, the complete obstruction of the main peripheral artery at the site of the aneurysm. The one exception is the restorative technic used for the pure saccular type. However, the true saccular form is in the minority. That sudden occlusion of a main peripheral artery may result in grave and uncontrollable consequences should be common knowledge to all surgeons who undertake the cure of arterial aneurysms. Therefore, the surgical treatment of an arterial aneurysm should never be undertaken until the surgeon has unequivocally satisfied himself that there is present an adequate collateral circulation to maintain a normal metabolism to the tissues distal to the point of obstruction of the main peripheral artery.⁸

To determine the presence of an adequate or inadequate collateral circulation, there is only one test that will give accurate information regarding the presence or absence of collateral blood flow. This test was devised by Matas,³⁻⁷ and is the only one that will obliterate the main artery proximal to aneurysm and concomitantly not interfere with the collateral circulation. This test is most simple in its application. It is performed as follows. A Martin rubber bandage is applied from the toes or fingers to a point just above the aneurysm. The Matas compressor³ is now applied to the main artery above the rubber bandage. The compressor is screwed down until the main artery is obliterated. The Martin rubber bandage is now removed. One must be absolutely certain that the compressor does not slip. The foot or hand immediately after the removal of the rubber bandage has a cadaveric color. The blanched toes or fingers are now carefully watched for the return of a pink color. The time interval between the removal of the rubber bandage and the return of color determines the presence of an adequate or inadequate collateral circulation. If the time interval is over three minutes, the collateral circulation is inadequate.

If by the above test it is shown that the collateral circulation is deficient, then operation should be deferred until an adequate one is developed.

The development of an efficient collateral circulation can be obtained by two methods. The Matas,³ or mechanical, and that of the author,⁵⁻¹⁰ the physiological. The former is by the daily application of the Matas compressor which obliterate the main artery proximal to the aneurysm. This shunts the blood through the collateral vessels. The length of time the compressor is applied increases daily. The latter method (author's) is accomplished by blocking out the sympathetic ganglionated chain which supplies the vascular tree of an extremity with 1 per cent novocain or by surgical removal of the ganglionated sympathetic chain. This physiologic

method is simple in its application and results in a very rapid development of the collateral circulation. Since 1934, the author⁵ has used this method extensively and its efficacy has been repeatedly demonstrated by others¹¹⁻¹². When it has been unequivocally demonstrated that an adequate collateral circulation exists, the patient is ready for operation. The next most important step is the absolute control of the blood flow through the field of operation. Unless the operation can be performed in an avascular field, the Matas endo-aneurysmorrhaphy should never be undertaken. If the blood supply both proximal and distal to an arterial aneurysm cannot be absolutely controlled, the aneurysmal sac cannot be opened. This is an inviolable rule of surgery of arterial aneurysms. Any surgeon who breaks this law will be immediately confronted with a most difficult situation and one that not infrequently ends in a catastrophe. There are two methods by which the operative field can be made avascular. The first, and most secure, is obtained by the application of a Martin bandage from the toes or fingers (only applicable to aneurysms of the extremities at least six to eight inches from the trunk) for a distance of eight to ten inches above the aneurysm. At this level a tourniquet is applied tightly around the limb. The rubber bandage is then removed leaving the operative field uncovered and completely avascular. The second method, not as secure as the first, is obtained by carefully dissecting out the arteries entering into the formation of the aneurysm, both proximal and distal to the aneurysmal, and applying temporary ligature (rubber catheters or rubber bands) to each vessel. In the majority of instances this is a very simple procedure because there is only the proximal and distal arteries to control. However, if the aneurysm is situated near the bifurcation of an artery, there may be more than the proximal and distal arteries to control.

When the above requirements are fulfilled, the patient is ready to be operated upon by the method of Matas, using either the restorative or the obliterative technic of endo-aneurysmorrhaphy. The type of anesthesia used can be either spinal or inhalation. The former is preferable for the lower extremities, whereas, the latter is superior for the upper extremities. The technical procedures of the operation (endo-aneurysmorrhaphy) are as follows:

After the anesthetic agent has produced its required effect, a Martin rubber bandage is applied to the leg or arm, beginning at the toes or fingers and extending the bandage above the aneurysm. A tourniquet is now applied above the bandage and the bandage is removed. The field of operation is thoroughly prepared and draped with sterile linen. An incision of sufficient length to give good exposure is now made over the aneurysm. The skin edges are protected with sterile towels and held in place by suitable towel clips. By sharp and gentle dissection the aneurysmal sac is now exposed. It is not necessary to completely expose the lateral walls of the sac. Being assured of perfect hemostasis, the sac can now be carefully opened. (It is important to examine carefully the relationship of the artery to the proximal and distal pole of the aneurysm before the sac is opened, because the sac

sometimes rotates on its polar axis and the proximal artery will run along the posterior wall of the sac. This artery may be injured when the sac is opened or the opening of the proximal artery into the aneurysmal sac will be difficult to locate.) The sac is now gently cleaned of its contents which consists of laminated clot and fluid blood. A diligent search is now made for the openings of the artery or arteries into the lumen of the sac. When they are identified a catheter, which has been previously anointed with sterile liquid petrolatum, is introduced into the openings. This is to determine their patency and to see if they connect with an artery. The catheter is discarded and the openings are closed with interrupted sutures of silk or cotton. The needle should take good firm bites through the lips of the openings. When all openings are closed the tourniquet is loosened to test the efficiency of the closure of the openings. This step is absolutely essential before the sac is obliterated, because if the openings are not thoroughly closed, a hematoma will form or another aneurysm may develop. If there is no bleeding from the sutured openings (occasionally a few extra sutures may be necessary to control oozing from the sutured openings), the aneurysmal sac is obliterated by layers of interrupted sutures of silk or cotton. These sutures should bring the walls of the sac together. The superficial incision is now closed and a pressure dressing is applied to the wound.

By using the above technic there has been no disturbance or interference with the vessels belonging to the collateral circulation. The vessels that are in juxtaposition to the sac of the aneurysm are likewise not disturbed—a most important and frequently overlooked detail when other surgical procedures are used.

The extremity is enclosed in two or three layers of cotton batting. Heat should not be applied to the extremity as it has been shown that heat increases the demands for greater vascular supply and if not forthcoming, there results varying degrees of anoxia which may bring about tissue destruction and necrosis. If the collateral circulation is adequate and is maintained, there should be no fear of ischemic necrosis of the extremity.⁷ If ischemic necrosis does occur, it is indicative of poor preparation of the patient for the operation.

The patient is kept in bed for 10–15 days postoperatively, then allowed up, and gradually returns to his or her former activities.

CONCLUSIONS

(1) Endo-aneurysmorrhaphy is the surgical procedure of choice in treating aneurysms of the peripheral arteries.

(2) There are only two types of endo-aneurysmorrhaphy that are applicable to aneurysms of the peripheral arteries. The restorative (saccular) type, and the obliterative (fusiform) type.

(3) An adequate and sustained collateral circulation must be present and satisfactorily demonstrated before the operation is undertaken.

(4) The collateral circulation can be developed by two methods. Me-

chanical (Matas method), and physiologic (blocking out the sympathetics, the author's method)

(5) Absolute hemostasis must be obtained and continued until the intrasaccular toilet is completed

(6) This operation is contraindicated in all arterial aneurysms in which the blood supply cannot be unequivocally controlled during the entire operation

(7) It is the simplest of all surgical procedures used for the cure of arterial aneurysms

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DISCUSSION—DR HERMAN E PFARSE, Rochester, N Y I have had very little clinical experience in aneurysms but thought it might be of interest to review briefly the matter of experimentally occluding the larger arteries The three different methods of attack in occlusion of the arteries are by external compression, by efforts to produce scar in the wall, and by internal occlusion

External compression may be done by the Halsted band, the Matas band, the Neff clamp, or by various types of ligatures of silk, catgut tapes, or fascia Doctor Halsted said that he could not accurately judge the tension necessary in the use of ligatures or tapes I was sorry Doctor Matas did not have the opportunity of telling more about his band, for it is very useful There are two other methods not illustrated, one, that of Doctor Matas, where he did plication of the aortic wall, another the elastic ligature of Owings Doctor Mont Reid is responsible for the statement that external pressure on the aorta will invariably result in atrophy and death of the vessel wall

The second method is by fibrosing the wall with diathermy, by injection of sclerosing solutions into the wall or by cellophane Three years ago I reported experiments on the fibroplasia caused by wrapping cellophane about the aorta of dogs In this I mentioned that in two of the 24 experiments there was no reaction. Subsequently, in another

series, a large number showed no response, the cellophane appearing inert in the tissues while in other animals an intense fibrosis occurred which shut off the vessel. Thus far, this discrepancy has not been explained but it is suspected that there is some substance in the cellophane, the presence or absence of which determines the amount of fibroplasia produced.

The third principle is by internal thrombosis. Doctor Mont Reid was the first to use this by means of placing a fascial plug with a tube in its center into the artery. Many years ago, while working in the Hunterian Laboratory, in Baltimore, I reviewed this subject, and came to the conclusion that internal occlusion offered the best means of obstructing the aorta. I attempted to insert metal tubes into it so as to cause gradual thrombosis, but found this difficult technically. So a tube was made of a coiled spring that could be screwed into the vessel through a puncture wound. This was successful, but has its disadvantages, for I find that one gets out of practice and hemorrhage occurs, so I do not advocate it as a final procedure. However, I do believe it demonstrates a principle which, if followed with better technical methods, may accomplish the result. I have returned to the opinion held 17 years ago that the aorta must be shut off from within.

MAJOR DAVID T. MONAHAN, Bridgeport, Conn. This is a brief report of a case of aneurysm of the terminal aorta treated by proximal ligation in stages, after the method described by Owings, in 1941.

Case Report—The patient was a Negro, age 49, who complained of abdominal pain and weight loss of 20 pounds. He had been under treatment for syphilis, the Wassermann test was positive. Physical examination disclosed a fixed, pulsating tumor just to the right of the umbilicus. He was operated upon in three stages, three weeks apart. At the first operation, March 20, 1942, the aneurysm was found to extend from about 15 inches below the renal arteries to the bifurcation of the aorta. An area about the size of a dime on the anterior surface was paper-thin. A rubber band, three-fourths of an inch wide, was placed proximal to the aneurysm and sutured in the shape of a funnel, so that about 75 per cent of the circulation into the aneurysm was interrupted. There were no circulatory symptoms after this procedure and the patient was out of bed in two weeks.

At the second operation a rubber band, one-half inch wide, was placed just below the site of the previous band, proximal to the aneurysm, and the circulation was shut off entirely. Postoperatively, his right leg was progressively cooler from the knee to the toes and there were fibrillary twitchings in the calf muscles of this leg, although he could move both legs without difficulty. These symptoms cleared up in a week except for some coldness in the right foot. He was allowed to go home for a week between the second and third operations.

At the third stage it was found that there was no circulation through the aneurysm. Two heavy silk ties were placed below the rubber band, both common iliacs were divided and ligated and the inferior mesenteric was ligated. Postoperatively, the patient again had coldness in the right leg and fibrillary twitchings for a week. He had considerable pain in his foot, which persisted.

He was discharged from the hospital in two weeks, was up and around and had no difficulty walking. The aneurysm could be felt only as a shrunken, firm mass. He complained of pain in his right foot persistently, and the advisability of paravertebral block was being considered when he had a massive hemorrhage into the gastro-intestinal tract, and died August 15, five months after the first operation.

Autopsy disclosed that a perforation had occurred into the third portion of the duodenum at a point just proximal to the proximal rubber band. Section through this area showed the aneurysm to be filled with old organized clot and at the area of ligation there was a band of tissue of cartilaginous consistency, without any vestige of a lumen. The silk sutures were found imbedded in the lower end of this band. The rubber was not apparent grossly and was presumably fused with the band of scar tissue, although the pathologist was unable to identify it. To the right of the aorta just proximal to the constriction was a new aneurysm filled with clot which communicated with the perforation.

The heart and kidneys were normal. Section of the aorta showed mild syphilitic aortitis.

DR. JOSEPH E. J. KING, New York City. I feel that we all regret very much that Doctor Matas did not have more time, and I hope he will have more to say in closing his discussion.

I shall limit my remarks to occlusion of the internal carotid artery in nine cases of intracranial arteriovenous fistula and two cases of intracranial aneurysm. Not having had access to Doctor Matas' band, and knowing of several cases in which death had occurred almost suddenly following ligation of the common carotid artery, I have employed the following method. To take the place of the Matas' band I have used ordinary skin clips, two being used and placed close together so that the artery would not so likely be cut through. The small sharp tips are broken off the clips, and then filed down. The clips are bent in the form of *omega*. A piece of fine plain catgut is tied in one of the eyelets of the skin clips so that in case quick removal is necessary it can readily be done. If there is no need for removing the clips, the catgut dissolves and the clips remain in place.

We have placed the two skin clips bent into the form of *omega*, around the internal carotid artery just beyond the bifurcation of the common carotid, and closed the skin clips down on the vessel until only the faintest bruit could be heard with a stethoscope placed directly over the eyeball. The intention is to shut off about three-quarters or four-fifths of the lumen, but not completely to occlude the lumen.

In the first two cases we reopened the incision in order that we might completely occlude the artery by further compression of the clips, but this was found to be unnecessary. In one instance the clips had completely and slowly divided the vessel, and both ends of the vessel were found to be firmly thrombosed. In the second case the vessel was almost cut through by the clips so that when the clips were more firmly and completely compressed, they cut through the remaining portion of the vessel without bleeding, *i.e.*, both ends had become firmly thrombosed. Therefore, in subsequent cases it has not been found necessary to completely close the clips at the second stage, and it is believed that complete thrombosis takes place slowly over a period of two or three weeks. At any rate, application of the clips in this manner succeeded in obliteration of the bruit and recession of the eyeball. Should it be necessary, the external carotid artery can be ligated and divided at the same time.

There were no deaths. One patient, a woman, had weakness in the opposite side for six or seven hours, but with elevation of the foot of the bed, no further weakness developed, and the weakness in the opposite side cleared up.

In the majority of cases the clips have remained in position, but in two or three cases they worked out to the surface and were readily removed with a thumb forceps. No damage has occurred to the vagus nerve or the jugular vein.

DR JOSEPH A. DANNA, New Orleans, La. I am very glad of the opportunity to lend my support to Doctor Gage's argument that the Matas operation for aneurysm is simple. Most articles written on this subject do not give the impression that it is a simple operation. Even what has been told you this afternoon I am sure does not leave that impression with you as clearly as I would like.

I have two criticisms to make of Colonel Gage's presentation so far as showing how simple it is. In the first place he made the incision two or three times as long as necessary. In the second place it is not necessary to obliterate the sac. There are some instances in which you cannot obliterate the sac. I have only done so in the first two or three cases in which I tried to do a restorative operation. The operation is very simple. You make an incision over the most superficial part of the sac. You can make it shorter than the length of the sac but never longer. Be sure you do not cut some important structures as you go down to the sac. After that you cannot injure anything. If you open the sac wide and cannot find any arterial opening you will probably readily find the openings by everting the edges of the incision and looking for them in the superficial wall of the aneurysm near the incision line. Once you have the sac open and the openings located it is very simple to put in a few sutures, as stated.

DR THOMAS B. AYCOCK, Baltimore, Md. I realize that Doctor Gage was speaking of aneurysms of the periphery rather than those which occur in the chest. Recently, however, I had one of the innominate artery, and, more recently one of the subclavian just distal to the innominate. I notice these have not been referred to and will relate briefly my experience. The first, I was not able to isolate. In retrospect, I wonder if the approach I used is not out of date. Both were approached anteriorly through the superior mediastinum. I have ligated the subclavian in its second part following accidental

injury to it by the posterior extrapleural approach, namely, by resecting the third, second and first ribs on the right, and I now believe it a better route to reach either the innominate or subclavian than the sternoclavicular disarticulation, which method I employed. I would like to hear what Doctors Matas and Gage have to say in this particular, if they have had any experience with aneurysms of this type.

DR ALFRED BLALOCK, Baltimore, Md (closing) I am sure you will all agree that it is a real privilege to hear Doctor Matas describe a patient operated upon by him 55 years ago. The fundamental principles regarding the treatment of aneurysm enunciated by Doctor Matas, in 1888, still holds.

I am sorry there was not time for Dr Duane Carr, of Memphis, to describe a patient with an aneurysm of the thoracic aorta who was operated upon by Dr John Alexander, of the University of Michigan, several months ago. The operation consisted of ligation of the thoracic aorta and the removal of the aneurysm. The fact that the patient withstood the complete occlusion of the thoracic aorta suggests that there might have been a coarctation of the aorta associated with the aneurysm. It would seem that there must have been some added incentive for the formation of collateral pathways, for it is well known that patients with thoracic aneurysms will not usually withstand ligation of the thoracic aorta. Doctor Carr informs me that this patient has a rather marked hypertension at the present time, and it might be that a procedure such as Doctor Park and I described today (or modification of it, such as Doctor Matas mentioned) should be considered.

The work of Dr Arthur Blakemore, of the Presbyterian Hospital, New York City, constitutes, in my opinion, one of the greatest advances that has been made in the treatment of aneurysms. This work has not received the attention which it merits. By the use of the wiring technic which he has described, one is able to cause an obliteration of aneurysmal sacs which cannot be attacked by other methods. It is my opinion that this procedure should be more generally adopted in the treatment of aneurysms of the thoracic and the abdominal aorta.

DR JOHN J MORTON, Rochester, N Y (closing) I have nothing to add, and I would welcome it if Doctor Matas would give us a little more information in his closing remarks. I came here to learn.

DR RUDOLPH MATAS, New Orleans, La (closing) How to relieve the grave effects of the congenital stricture or stenotic coarctation of the aorta caused by developmental defect, by creating a new blood channel which will bridge over the obstruction and restore the continuity and volume of the aortic stream, is one of the new, but still distant, problems of intrathoracic surgery which Doctors Blalock and Park have ingeniously, and with great perseverance and skill, attempted to solve. It is a fitting example of the type of operations which would have been dismissed as purely chimerical or outside the domain of practical or rational surgery, 25 years ago, but have now become tangible as experimental and clinical realities.

In the present experimental inquiry, the authors, particularly Doctor Blalock,* have brought to its performance the benefit of a previous experience in aortic surgery by his studies on the "Effects of Complete Occlusion of the Thoracic Aorta *etc*." In the present investigations the authors have had to deal with two problems as these apply to the dog: (1) The creation of a stricture, coarctation or total occlusion of the thoracic aorta in imitation of the congenital strictures in man, (2) the creation of a blood channel, or arterial duct, to connect the proximal with the distal side of the obstruction, thereby restoring the blood stream to the distal side. In the dog, this means two problems to be dealt with, in man, only one, since the stricture or obstruction already exists and the only problem is how to restore the continuity of the aortic stream.

Experimentation and clinical experience with various methods of ligation since the days of Astley Cooper, who first (1817) ligated the abdominal aorta in man, have shown that the *sudden total* occlusion of the aorta in normal individuals is fatal, and that the period of survival is generally directly proportional to the proximity of the ligature to the heart. It is only in individuals who have suffered from a long-standing obstruction

* Jour Thoracic Surg, 2, No 1, 69-75, October, 1932

in the aortic stream (*ie*, aneurysm) that a total occlusion may be followed by survival, solely because the collateral circulation has had a chance to develop

In the same way it is now well established that the gradual occlusion in several stages of the aorta throughout its tract from the subclavian to the bifurcation, is compatible with survival (Halsted, Matas, C Allen, Reid, Pearce, Owings, *et al*) Even the total, but gradual, obliteration of the great trunks that spring from the aortic arch (innominate, carotids and subclavian) is compatible with life, if time is given for the development of the collateral circulation by way of the intercostals

In their experiments, the authors have aimed at an immediate and complete occlusion of the aorta at the so-called isthmus of the arch, immediately outside the subclavian, which is the usual seat of the congenital occlusion in the so-called "adult" type (Bonnet) in postnatal life, *ie*, a few millimeters from the level of the obliterated ductus arteriosus

I need not rehearse the steps of the operation which Doctor Blalock has so well described and illustrated It is well to note, however, that our authors tried in their preliminary experiments to obtain the occlusion of the aorta by Owings' method of gradual obliteration in three stages, in which the artery was compressed progressively with a rubber band shaped like an hour-glass

In 1940, when, through the courtesy of Doctor Owings, I first described his procedure at the meeting of the American Surgical Association,* I believed that the use of a rubber band shaped like an hour-glass was a valuable suggestion, as the elastic rubber would yield to the impact of the aortic stream as this entered the hour-glass in a conical shape, thereby diminishing the tendency to atrophy of the aortic wall at the proximal (cardiac) margin of the band

The admirable results obtained by Doctor Owings in his experimental occlusions of the thoracic aorta fully confirmed the theoretic advantages of the method, and my own belief that the major difficulties in the control of the aorta had been overcome But the unexpected outcome of the remarkable operation for an ilio-aortic aneurysm, which Major Monahan has just read, and of which I had been previously informed through his courtesy, made me realize that what seemed to be a simple and safe procedure had also its pitfalls and fallacies when performed in pathologic human subjects For, in the operation reported by Major Monahan (the occlusion of the aorta for an aneurysm of the common iliac, at the bifurcation), the application of the Owings' band to the aorta in three sittings had accomplished its purpose in controlling and suppressing the aneurysm without apparent complications The patient, apparently well, had returned to his regular mode of life when suddenly he died as the result of a profuse and uncontrollable gastro-intestinal hemorrhage At the autopsy, it was found that death had been caused by the rupture of a small aneurysm which had developed in the aorta immediately above the edge of the rubber band on the proximal side of the band The sac had contracted adhesions with the duodenum into which it ruptured with fatal results The aorta had been thinned and stretched into an aneurysmal sac by the pounding of the aortic current against the upper edge of the rubber band Thus it was, that what seemed to be a most perfect and brilliant success proved, in the end, to be an unpredictable and disastrous failure The experience of Doctors Blalock and Park with a procedure very similar to that of Doctor Owings was complicated by hemorrhages at the seat of the constriction more often when the constriction was increased at the second stage of the procedure This led the authors to adopt the original procedure which Doctor Blalock has just described

The vital step in this operation is the successful transplantation of the subclavian artery to the distal segment of the divided aorta Failure to keep this channel in functional activity means the prompt death of the animal Thrombotic occlusion is also fatal, as five cases seemingly ended in this way

As the anastomosis between the proximal aorta and the distal segment is effected by an end-to-side anastomosis of the subclavian to the aorta, the liability to mechanical occlusion by the kinking of the subclavian channel at the line of suture makes it more liable to occlusion than a straight end-to-end anastomosis The vital importance of this anastomotic subclavian bridge is well demonstrated by the fact that the general arterial pressure which is uniformly sustained as long as the subclavian channel is functioning, becomes unbalanced when for any reason the subclavian channel is blocked

* ANNALS OF SURGERY, 112, 909-922, November, 1940 *Ibid* 115, 596, 1942

Then the blood pressure in the head and vascular region supplied by the branches of the aorta above the line of aortic section, begins to rise progressively while the blood pressure in the territories supplied by the aortic branches of the lower segment, begins to drop progressively and fatally. In this way, the experimental coarctation of the aorta reproduces the condition that prevails in the clinical cases of marked congenital aortic stenosis in which the hypertension in the vessels of the brain and upper extremities and the hypotension in the lower extremities and vascular areas below the aortic stenosis are distinctive characteristics.

That the incidence of these coarctations is far more frequent than is estimated in the general statistics of postmortem findings (about 1 in 2300, Fawcett, 1902, 1 in 1500, Bramwell and King, 1942) is the opinion of observers such as Liebman, who was especially interested in finding them. The more frequent clinical discovery of this anomaly is also in accord with our experience with other disorders which have become far more frequent since roentgenologic and other more accurate ways of clinical investigation have made them more apparent and recognizable (patent ductus arteriosus, bronchogenic carcinoma, aortic aneurysm, appendicitis *etc*).

One of the interesting questions brought out by Blalock and Park is the fact that after the occlusion of the aorta by their operation, the general blood pressure gradually rises from the relatively low hypotension at or shortly after the operation to an increasing hypertension in the carotid and femoral tracts, which progressively follows in from four to ten months after the operation. The reasons for this progressive systemic rise in the blood pressure are not clear, despite the assumption that the general hypertension is a reactionary response to renal ischemia caused by the lowered vascular supply of the kidneys and other organs below the experimental coarctation, as suggested by Goldblatt's theory of hypertension following a partial occlusion of the renal arteries.

The fact that more than 23 per cent of the animals have survived this formidable, but very skilfully planned, operation is in itself a great compliment to the skill and perseverance of the operators. The complications from technical defects (thrombosis, hemorrhage) are presumably avoidable, but, thus far, the one complication that seems to be specifically peculiar to the total acute experimental occlusion of the aorta in dogs, is paralysis of the hind quarters, which occurs "in about 50 per cent of the animals, varying from a short transitory weakness of the legs to a more or less lasting spastic disability in a few." While this is related to an ischemic disturbance in the circulation of the lumbar cord and cauda equina, the mechanism by which this occurs still awaits a clear explanation.

In eight of the animals operated upon by the authors, the cause of death was not discovered, showing that death may occur after this operation in spite of apparent good technic and physiologic restoration of the aortic flow.

There can be no question that many minor aortic coarctations of large caliber exist without causing appreciable disturbance in the life of the individual. While it is universally recognized that the effect of a stricture of narrow caliber is, in general, to shorten life and is liable to cause sudden death from cerebral hemorrhage, dilatation of the heart, ruptured aneurysms of the ascending arch of the aorta, and other effects of the progressive hypertension in the vessels proximal to the obstruction, it is also true that life is compatible with even advanced old age, despite a practically complete occlusion of the aorta at the coarctation (92 years Reynaud), the patient's life expectancy largely depending upon the development and efficiency of the compensatory circulation through the intercostal collaterals. In view of this compensatory circulation, the indications for such grave and adventurous operations as that suggested by the authors' experimental study would be very rare indeed, even granting the feasibility in the human subject.

GENERAL CONCLUSIONS

It would seem from the evidence gathered in this carefully and skilfully conducted experimental study

1 That the operation devised by the authors for the relief of congenital coarctations, stenoses or atresic obstructions of the thoracic aorta is technically feasible, and has

proved successful in accomplishing its purpose in a fairly large proportion of the dogs in which the operation was performed, (10 of 43, or more than 23 per cent)

2 That the experimental study devoted to the practicability of producing an arterial blood conduit to bridge over a permanent obstacle in the aorta is a valuable contribution to the technic of experimental aortic surgery, and the study of the secondary hypertension following in the wake of this operation is another valuable contribution that has come out of this study

3 Unfortunately, the operation, as applied successfully on dogs by the authors, is not applicable to human subjects, as admitted by the authors, because the anatomy of the subclavian in man does not permit of the transplantation of this artery from its extrathoracic cervical bed to the aorta without fatal damage to its important cervical collaterals, besides the permanent damage inflicted on the main arterial supply of the arm

4 The use of the carotid as a substitute for the subclavian for the same purpose would involve serious difficulties in the transplantation of that artery from the neck to the thoracic aorta. In addition to the objections stated by the authors, there is the liability of cerebral complications which add to the gravity of the procedure and make its performance scarcely justifiable except as an adventure in desperate cases

5 That in attempting to relieve the sufferers from the effects of a congenital coarctation of the thoracic aorta in which the essential or fundamental problem consists in restoring the continuity of the aortic stream, a much simpler and presumably less hazardous procedure would be to divide the aorta at the seat of stricture and connect the divided segment by a vitalium tube lined by an autogenous venous graft, in the manner suggested by Blakemore, Lord, and Stefko *

6 While the experimental evidence thus far available is in favor of the practicability of veno-vitalium grafts, the further study of this procedure as permanent blood channels in this connection, is desirable in an effort to simplify the attainment of the, at present, very important but difficult objective, namely, the permanent repair and functional restoration of the larger damaged arteries

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EDITORIAL ADDRESS

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ANNOUNCEMENT

AN ARMY EVACUATION HOSPITAL at Charlottesville, Va , organized under University of Virginia sponsorship, has celebrated the completion of its first year of overseas service by presenting to the University of Virginia a set of surgical instruments which are exact reproductions of instruments used 2000 years ago and found in the ruins of ancient Pompeii and Herculaneum

Three boxes containing the 57 historic reproductions have been received by President John Lloyd Newcomb and have been turned over to Dr Harvey E Jordan, Dean of Medicine They will be placed on exhibition in the library of the medical school

Original instruments from which the reproductions were made are in the national museum at Naples The instruments were found in the ruins of the cities buried in the eruption of Mount Vesuvius in 79 A D , and most of them were in use long before that date

Cavalier Guhelmo Callo made each of the reproductions by hand from the metal originally used, usually bronze They have been antiqued to look like the original by a secret process

Lieutenant-Colonel Staige D Blackford, member of the university faculty and chief of medical service of the Evacuation Hospital has sent the gift with an explanation that it was made possible by contributions from doctors, nurses and administrative staff members

President Newcomb has written in appreciation, assuring the donors that their gift will serve "to stimulate interest in the history of medicine on the part of future generations of University of Virginia medical students"

Ancient surgical instruments in the set of reproductions include a variety of forceps, speculum, curettes, probes, blood cups, hooks, scissors in several sizes, irrigating canula, spatulas, cauteries, needles, knives and bistouries, a tongue depressor, a tenaculum for molars, *etc* There are two historic pictures in the collection

The evacuation hospital was organized in the Winter of 1942 It served in North Africa

SGT GEORGE E TOLES,
Post Public Relations Office,
Camp Lee, Va

The publishers of the *ANNAIS OF SURGERY* regret the late appearance of this issue Shortages of manpower the busy schedules of contributors and other factors beyond our control made it impossible to publish on the usual date —The Editors



NEWER ASPECTS OF RUPTURED INTERVERTEBRAL DISKS*

WALTER E DANDY, M D

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INSPECTION OF THE SPINAL COLUMN explains the cause of defective lumbar intervertebral disks, their frequency and the fact that they are nearly always multiple or potentially multiple. The key to these disclosures lies in the lateral facets of articulation between the vertebrae. The first and second lumbar articulations parallel the spinous processes and prevent not only lateral but little forward, backward or side motion. At the third lumbar articulation the lateral articulations usually, but not always, begin to turn outward from the horizontal plane, and as far as 25° . The fourth articulation turns laterally to as much as 45° , and the fifth may reach 90° . Doubtless the purpose of the directional shift in the facets is to provide movement and flexibility of the spinal column, but at the same time it creates a potential weakness in the spinal column. There are many variations at all of these points and much asymmetry between the two sides but this tendency is always present. In addition, some of the facets are round, others oval, some concave and convex, others flat. These differences account for further weakness at these points.

The sequence of events in low back pain and sciatica is, I think, as follows: (1) A sudden, severe lift, or twist, tears the capsule at the lateral articulations, and loosens the joints. (2) These loose joints automatically throw an additional strain on the intervertebral cartilages, which is the third component in the articulations between the vertebrae. (3) The result of this sustained trauma is an injured disk which protrudes and impinges upon the emerging spinal nerve lying immediately in contact with the intervertebral disk.

Since the three articular facets of the three lower vertebrae participate in the anatomic variation, the high incidence of multiple disks is to be expected and actively obtains in practically all cases. In at least 5 per cent of the cases three disks are present at the time of operation, or will subsequently develop. Without a proper appreciation of multiple disks, any operative treatment will be ineffectual. This is one of the principal reasons for the disappointing results in the past.

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La

TEST FOR MOBIL JOINTS

When the articular facets become loose the whole vertebral junction is similarly affected. The abnormal mobility can be determined at operation by pushing a spinous process in the horizontal direction. And, conversely, if this test shows mobility there are defective articular facets and at the same time a defective disk. This test is, I think, absolute with one exception, *i e*, when the roentgenogram shows a reduced interspace, a fusion or partial fusion has then occurred and this may or may not reduce or entirely eliminate the movement the result depending upon the duration and degree of fusion. This is nature's attempt at curing a disk—the contents of the disk having gradually absorbed over a period of many years, but the protrusion may remain and compress the nerve.

TREATMENT

Nature's method of absorbing a disk is the key to the proposed surgical treatment, *i e*, complete or essentially complete removal of the affected disks. This is done by thoroughly curetting the interior of the disk, extracting its contents and at the same time removing the protruding portion. The end-result is fusion of the entire vertebral surfaces. There have now been 30 cases in which at an earlier period a single disk has been removed and return of symptoms necessitated reopening the wound for a second disk, after six months the vertebrae at the site of the first operation are absolutely fixed when the disk has been completely removed. Unless a disk is thoroughly removed (*i e*, if only the protruding sequestrum of cartilage is extracted) the surfaces will not fuse, the joint remains mobile and it is more than probable that a new protrusion (recurrence) will form. The end-result of a cured disk is, therefore, firm fusion of the apposing surfaces of the vertebrae. Furthermore, by this treatment when properly done, a cure must result and if the pain returns another disk must be the cause.

IDENTIFICATION OF DISKS

There are varying degrees of protrusion of disks, the smaller ones, that would not show with contrast media in the spinal canal, I have termed "concealed" disks, and these are two-thirds to three-quarters of the total number. Some of these bulge only slightly, but they fluctuate and in most instances are bound to the surrounding epidural tissues by adhesions which indicate that they must have protruded more than appears at operation. It might well be asked whether some of these are really abnormal. I am not sure. At necropsy much the same appearance has been found but without adhesions, *i e*, they protrude slightly and fluctuate. Of this I am certain, if there is abnormal mobility of the joint, removal of the disk is the only method of obtaining successful treatment, and it will be successful. With periodic backaches there is always a loose joint and this is almost the only cause of such backaches. Moreover there is no difference except in the degree of

sciatica, between the cases having large protrusions and those with the concealed disks

It is natural to ask why fusions by autogenous grafts to the lumbar spine will not accomplish the same result. The answer is that with a graft fusion the protruding disk is merely covered up and continues to cause sciatica. And in several cases that have been fused the backache persists as well as the sciatica because of the defective disk. There can be no fusion so complete and effective as that obtained by denuding the broad surfaces of the vertebrae. Moreover, fusion by removing the disks is simple and requires but a week or ten days in the hospital. A spinal graft is a big performance and requires a plaster encasement for six weeks and a prolonged stay in the hospital, and will not produce a cure.

DIAGNOSIS AND LOCALIZATION OF THE DISKS

Neither the diagnosis nor the localization of disks require intraspinal injections. They miss over two-thirds of the disks (concealed disks) and the history alone is almost pathognomonic, *i e*, periodic attacks of low backache plus sciatica both usually (but not always) made worse by coughing and sneezing (because of the mobility of the joint). The *localization* of the defective disk or disks (mobile joints may be preferable) is perfectly simple and certain by the mobility test* described above. The only possibility of error in diagnosis is a spinal cord tumor. These occur in a little less than one per cent of the cases. This is, indeed, a difficult and often impossible differential diagnosis to make solely from routine examinations, but is no excuse for subjecting the 99 per cent to intraspinal injections. If the diagnosis is suspected a lumbar puncture alone is indicated—the fluid will be xanthochromic if a tumor is present, there may or may not be a positive Queckenstedt test. I have missed five tumors in the series of 900 disks—700 patients.

Recently we have treated 15 cases of backache without sciatica, six with congenitally defective lumbar vertebrae, and ten with spondylolisthesis, by the same procedure *i e*, removal of the intervertebral disks to produce vertebral fusion. The results in backache without sciatica are precisely the same as those with sciatica. Sufficient time has not elapsed to determine the results in the defective vertebrae and spondylolisthesis.

Before concluding I should like to call attention to a medical classic that I have never seen mentioned, namely, that of Goldthwaite, of Boston, published in 1911. The anatomic weakness of the spinal column to which I have alluded has long been known to orthopedists and has been considered by them to be the potential source of low back pain and sciatica. Indeed Ghormley has very aptly called it the "facet syndrome" which is probably responsible for the backache. But Goldthwaite not only described the ana-

* This test was shown to me by Dr Ray E. Lenhard when demonstrating a congenitally defective lumbar vertebra. It was then tried on the disk cases and found to be all-important.

tomic variation of the three lumbar facets and ascribed to them the low backache, but he postulated the development of ruptured intervertebral disks upon the same basis, and this was 18 years before the first disk was found at operation. This remarkable anticipation of ruptured disks and their cause was made from careful studies in the anatomical laboratory and was prompted by a negative surgical exploration in one of his patients whose symptoms he always maintained could only be caused by a ruptured intervertebral disk.

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SPONDYLOLISTHESIS*

ANALYSIS OF FIFTY-NINE CONSECUTIVE CASES

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SPONDYLOLISTHESIS has been recognized for more than a century. Etiologic theories still differ although most writers agree that the defect is congenital in origin. Clinical recognition of the condition was confined at first to those cases in which forward slipping of the spine had occurred (spondylolisthesis). It has only been a few years since roentgenologic technic has made possible the recognition of defects of the neural arch even when there has been no displacement (prespondylolisthesis, spondylolysis). There can be little doubt that low back pain may be caused by the defect in the neural arch despite the fact that slipping cannot be demonstrated. Likewise, the condition may be asymptomatic even if the displacement is Grade IV (Meyerding's classification). The absence of symptoms in many cases, regardless of the extent of displacement, makes evaluation of treatment difficult.

Incidence—The incidence of spondylolisthesis and spondylolysis, with and without symptoms, has been estimated from anatomic studies to be about five per cent, but can be determined accurately only when careful and exact roentgenologic studies of the lumbosacral region have been made on a large group of persons without regard to back complaints. Whether or not there is an inherited tendency toward such defects cannot be determined until a number of family groups has been studied. Among 61 members of one family Friberg¹ observed 15 persons with spondylolisthesis, only three of whom had symptoms although all but one were engaged in heavy labor.

TABLE I

SPONDYLOLISTHESIS AND SPONDYLOLYSIS OBSERVED AT THE OCHSNER CLINIC

January 1, 1942–November 1, 1943

Spinal fusion	8
Brace or corset	26
No treatment	15
Incidental finding	5
Incomplete data	5
Total	59

Fifty-nine cases of spondylolysis and spondylolisthesis were seen at the Ochsner Clinic from January 1, 1942 to November 1, 1943 (Table I). This number represents 0.3 per cent of all admissions to the Clinic during

*Read before the Southern Surgical Association, December 7–9, 1943. New Orleans, La.

this period The average age, sex distribution, site and occupation are shown in Table II Between January 1, 1943 and June 1 1943 there were

TABLE II

	Spondylolysis	Grade I	Grade II	Total
Average age	39	39	36	38
Sex—Male	9	21	4	34
Female	7	16	2	25
Site—				
I IV on L V		5		5
L V	15	32	6	53
Unknown	1			1
Occupation—				
Sedentary	8	28	6	42
Labor	7	5		12
Unemployed	1	2		3
Unknown		2		2

152 cases with low back complaints 15 (10 per cent) of which were found to have neural arch defects (Table III) Of the 152 cases 82 were re-

TABLE III

INCIDENCE OF SPONDYLOLISTHESIS TO LOW BACK PAIN

January 1 1943—June 1 1943

	No of Cases	No of Cases
Low back pain		152
Examined in orthopedics	82	
Spondylolysis or spondylolisthesis	15	
Incidence of spondylolisthesis to low back pain		9.9%
Incidence of spondylolisthesis to orthopedic complaints		18.3%

ferred to the Orthopedic Department for examination, and of these, 18.3 per cent were found to have spondylolisthesis or spondylolysis Thus, it is seen that among those with low back complaints severe enough to require medical attention, one out of ten is liable to have spondylolysis or spondylolisthesis and of those referred to Orthopedics after other conditions have been ruled out, one out of five has neural arch defects Thus, spondylolisthesis represents one of the commonest causes of low back pain seen by the orthopedist

Since the classic description of spondylolisthesis by Turner and Tchirkin² in 1925, most clinical descriptions have followed the same pattern This is misleading, however, since it portrays an advanced case (Grade IV), whereas most of the cases seen now are spondylolysis, or Grade I spondylolisthesis, and have symptoms and signs similar to other low back lesions and spondylolisthesis can be differentiated only by roentgenographic examination

History—In most reported series the average age is around 35 years, and the duration of symptoms prior to examination about seven years In approximately half the patients there is a history of abrupt onset of symptoms associated with injury or with repeated heavy lifting strains In my series of 54 cases, 27 (50 per cent) gave a history of trauma Pain is felt in the lower lumbar region at the lumbosacral junction usually extending to both sacro-iliac joints and radiating either to the groins and down the anterior aspect of the thigh or along the course of the sciatic nerve,

occasionally as far as the leg and ankle. In most cases symptoms completely disappear when the patient lies down and rests. The more severe symptoms are often caused by standing in one position or by bending and stooping or attempting to lift.

Physical Examination—Physical examination may be almost completely negative or may reveal a definite apparent deformity with serious limitation of motion, muscular spasm and disability. Although the lumbar lordosis is often exaggerated, in some cases the back is perfectly flat. Some degree of muscular spasm is present in most patients with active complaints and is associated with definite limitation of motion at the lumbosacral junction.



FIG. 1.—Lateral and 35° interoposterior views showing bilateral defects of the neural arch.

tion. Typical shortening of the back, increased prominence of the buttocks and iliac crest and an abrupt stepping-off of the spine at the level of the spinous process of the fifth lumbar vertebra is present only in those cases with third and fourth degree spondylolisthesis. In none of my series, which included only spondylolysis and Grades I and II spondylolisthesis, as revealed in the roentgenograms, was the displacement great enough to be determined by inspection or palpation at physical examination. In most cases the pain of which the patient complains is reproduced when the patient is lying on his back by hyperflexing the spine and rocking the pelvis from side to side. Tenderness is usually sharply localized to the spinous process of the fifth lumbar vertebra (or the fourth, when this is the level of the lesion) with slighter tenderness in the lumbosacral angle on either side.

Roentgenologic Examination—The importance of precision in making routine roentgenograms of patients with lumbosacral pain cannot be too strongly emphasized. The most exacting technic should be employed and should include a *minimum* of three views, because routine anteroposterior and lateral views fail to visualize the neural arch defects unless gross displacement has occurred. The three views are (1) Direct anteroposterior

view, (2) a true lateral view focussed on the fifth lumbar vertebra, and (3) a 35° anteroposterior view, with the rays directed toward the head and centered between the sacrum and fifth lumbar vertebra (Figs 1 and 2). This projection has been used routinely by Dr E H Little, Director of the Department of Roentgenology, for examination of the lumbosacral region and has been found to be most helpful. These views will clearly define any neural arch defect with separation—and most of them without separation. Unilateral neural arch defects may require confirmation by 45° oblique lateral films but these are not essential for routine examination, although they confirm the findings and visualize them better. In my series of 59 cases there were 16 with spondylolysis, nine of which had only unilateral defects, 37 had spondylolisthesis Grade I and six had spondylolisthesis, Grade II.

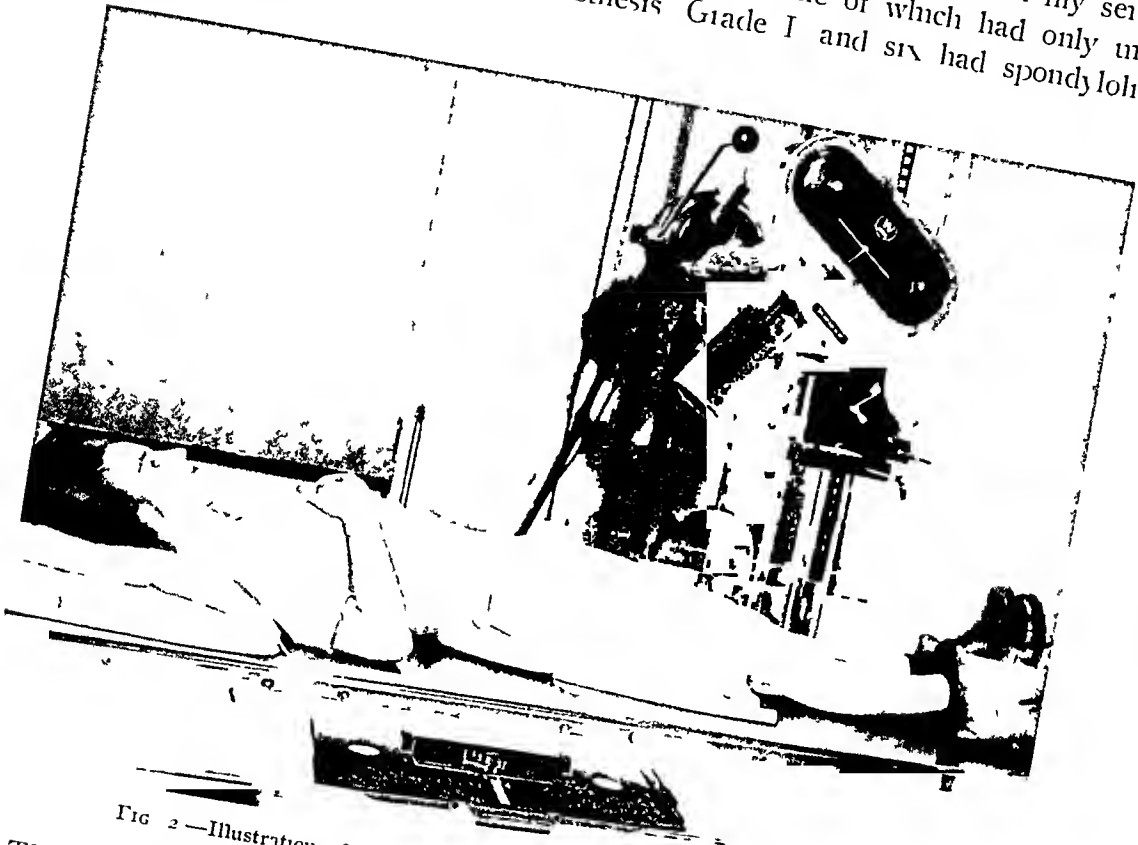


FIG 2—Illustration of technic used in making 35° anteroposterior view

The diagnosis of spondylolysis and spondylolisthesis, Grades I and II, therefore, necessarily hinges upon the roentgenologic findings, since symptoms and physical examination may suggest any of the low back lesions, such as lumbosacral arthritis, ruptured intervertebral disk, unstable asymmetrical articular facets or other anomalies.

Production of Symptoms—Most investigators have attributed the symptoms of spondylolisthesis to progressive displacement with consequent drag upon the supporting muscles and ligaments and nerve roots in the vicinity. This assumption appears plausible since all degrees of displacement are

observed and in many cases the symptoms date from trauma which might increase the stretch and strain or actual displacement of the spinal column on the subjacent sacrum or vertebra. Nevertheless, the theory of progressive slipping was questioned, in 1937, by Bakke,³ who reported a small series of cases with no slipping after being under observation for several years, and about the same time Brofeldt⁴ also stated that slipping had not been proved in any published case. In 1939, Friberg,¹ of Stockholm, published an excellent monograph, "Studies on Spondylolisthesis," based on a review of 280 patients observed between 1927 and 1938, personally interviewed and examined by the author and supplemented with detailed, competent roentgenologic studies made at intervals of two to ten years and compared with former films. He endeavored to answer two questions (1) At what age does slipping occur? (2) How do results of surgical treatment compare with those of conservative therapy? This was a most comprehensive, thorough and painstaking analysis, the accuracy of which cannot be doubted. In regard to the first question, he concluded that because the number of children examined for spondylolisthesis was too small and was observed over too short a period, nothing definite could be established regarding the onset of slipping. He further reported that in 142 nonoperative cases a change of position of the body was noted in ten cases, in only two was this change in the sagittal direction. Both of these had Grade IV spondylolisthesis when first examined between the ages of 10 and 15 years. Having excluded slipping as a cause of symptoms, he suggested that arthritic changes, noted in many of his cases might possibly produce the pain.

On the other hand, George⁵ who, in 1939, reported observations on 91 cases of spondylolisthesis over a period of several years, noted an increase in the anterior displacement of the affected vertebral body varying from one-sixteenth to five-eighths-inch in five patients while under observation. He concluded "The paucity of cases and the slight degree of increased slipping of the affected vertebra would tend to indicate that there is not a marked tendency for the deformity to increase."

Hitchcock,⁶ in 1940, reported three cases in which the roentgenograms indicated progression from spondylolysis to spondylolisthesis. Two of these were in children and one in an adult. He states "The roentgenograms of these cases present examples of spondylolisthesis in which may be found undoubted objective evidence of progressive forward migration of the vertebral column. In all of these cases progression of the listhesis was accompanied in greater or lesser degree by roentgenographic evidence of thinning of the related intervertebral disk. This is a feature in spondylolisthesis which must be regarded as of considerable importance not only in the development of the listhesis itself, but also in the development of an osseous barrier to hinder further progression of the slipping."

Although George and Hitchcock's observations contradict the theory that slipping does not occur, they confirm Friberg's statement that it prob-

ably seldom occurs in adult life and the exact age at which the major displacement takes place has not yet been established. It can be said, however, that slipping and further displacement probably do not cause the symptoms of which the patient complains. The progressive narrowing of the intervertebral disk with degenerative changes in the disk and proliferative changes of the bone in the neighborhood of the intervertebral foramen may readily explain all of the symptoms and signs generally seen in spondylolisthesis (Fig 3).

Treatment—Treatment of spondylolisthesis, hitherto, has been directed toward improving the support of the lumbosacral portion of the spine. This is based upon the assumption that such support should provide relief by taking the stretch and strain off the ligaments and muscles and reducing the possibility of progressive slipping and displacement of the vertebra.

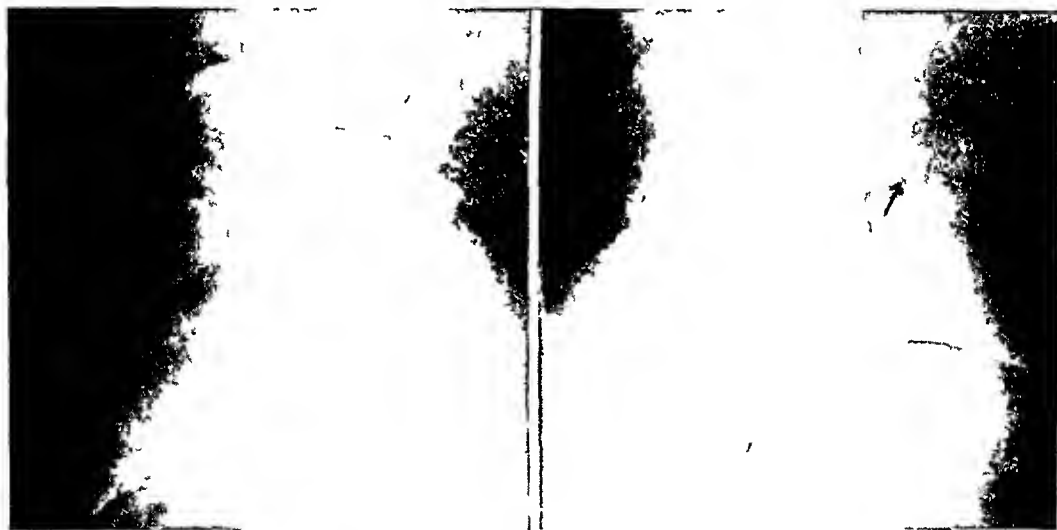


FIG 3—Roentgenograms illustrating narrowing of the intervertebral disk, impingement of bony surfaces and early associated arthritic changes which might produce symptoms of spondylolisthesis.

Conservative Treatment—Results of conservative treatment as reported by various authors are admittedly poorer than the best results obtained by operative fusions, nevertheless, when well directed conservative measures have been carried out consistently, the degree of improvement has been considerable. Furthermore, it seems probable that even better results could be obtained if surgeons themselves gave more thought and attention to planning and directing such measures.

Of the 26 patients in my series treated with a brace or corset, 23 were followed from 10 to 18 months. Those who reported that they were relieved of pain while wearing the support and were able to perform light work with the help of the support were considered as having a good result. Those who obtained partial relief from pain and were unable to carry on light work regularly without aggravating the symptoms were considered to have fair results. Those with no relief of symptoms and unable to do any work

were classified as poor results. Seven of the 23 patients had good results, 12 fair and four poor (Table IV)

TABLE IV
RESULTS OF TREATMENT

Results	Conservative (Braces and Corsets) Observed 11-23 Mos
Good	7 (31%)
Fair	12 (50%)
Poor	4 (19%)
Total	23 (100%)

The results obtained in those treated by conservative measures depended to a great extent on the cooperation of the patient. Those who wore the brace consistently usually found it possible to carry on any activities consistent with wearing the brace. Hardly any of them could lift objects or stoop over. The majority complained of the discomfort caused by the support and found it possible to get enough relief from rest and restricted activities. They preferred to follow this routine rather than to undergo operation or wear the support continuously. In many cases when the patient had overtaxed his back, he discovered that he could get relief by wearing the support for a few days and then discarding it. Approximately 80 per cent were, therefore, materially improved by the conservative treatment.

In only one or two cases did the patient carry out weight-reducing regimens with postural exercises and physical therapy, but in these cases the results were excellent and they were able to do active work including a moderate amount of bending and lifting without wearing a support. Men doing heavy labor usually found it necessary to change to a lighter occupation, which they were able to perform without wearing a support most of the time.

Although this series of cases treated conservatively is admittedly small in comparison with those of Meyerding,⁸ Friberg,¹ and George,⁶ the trend of results of treatment is similar to the results of a large series of cases reported by Friberg, who obtained good results in 80.3 per cent of cases.

Operative Treatment—The assumption that progressive slipping occurs and that the severity of symptoms depends on the amount of displacement suggested that if a sufficiently strong bony bridge could be established from the sacrum to the third and fourth lumbar vertebrae posteriorly, it would serve to prevent further displacement and alleviate the pain. Spinal fusion operations of various types have been carried out by many surgeons over a period of years with a report of a high percentage of complete relief from symptoms (George,⁵ 81.3 per cent, Friberg,¹ 81.8 per cent). Others, notably Meyerding,⁸ and Chandler,⁹ imply a high percentage of cases completely relieved by the operation although followed only for a short time. It is interesting to note that in all series of surgical cases reported some patients failed to obtain complete relief despite roentgenologic evidence of solid fusion postoperatively. On the other hand, failure of fusion occurred in

20 to 25 per cent of cases, and of these, a number was completely relieved of symptoms, although the operative procedure was a failure

Most authorities agree with George, who says, "when the pain becomes so severe that the sufferer demands relief not obtained by conservative methods of treatment the operation is definitely indicated" The preference for operative treatment of spondylolisthesis is based upon the assumptions that (1) progressive slipping does occur, (2) symptoms are the result of progressive slipping, (3) spinal fusion prevents slipping and thereby relieves the symptoms, and (4) bracing, corseting and physical therapy are not adequate to check slipping and hence do not relieve symptoms

Friberg, in contrast, believes that, "the conclusion must be drawn that there is no slipping of either the spondylolytic or the olisthetic vertebra during adult life This observation must change our attitude toward the question of operation"

In my series, spinal fusion was performed upon eight patients They were observed from ten to 23 months, in three, the results were good, in one, a fair result was obtained, but in four, fusion failed to occur and the results were indifferent (Table V) Failure of fusion in the operative

TABLE V
RESULTS OF TREATMENT

Results	Lumbosacral Spinal Fusion Observed 10-23 Mos
Good	3 (40%)
Fair	1 (10%)
Poor	4 (50%)
Total	8 (100%)

cases was undoubtedly due to errors in technic in some and perhaps to inadequate postoperative support in others One patient whose operation was a failure has been subjected to a second operation in which the clothespin-type of graft, suggested by Bosworth⁷ was employed Those who obtained poor results are wearing a support, corset or brace part of the time which enables them to perform light occupations

SPONDYLOLISTHESIS ASSOCIATED WITH SCIATIC PAIN

In 1941, Meyerding⁸ reported a series of 80 cases of spondylolisthesis associated with sciatic pain, 49 (61.3 per cent) had conservative treatment, 25 (31.3 per cent) had surgical fusion alone, and in six (7.5 per cent) surgical fusion was combined with removal of an intervertebral disk Meyerding believes that in cases of sciatic pain and spondylolisthesis it is best to combine removal of the protruded disk with lumbosacral fusion In my series there was one case which suggests that associated sciatic pain may arise from another cause, *viz*, involvement of the nerve root in proliferated bone

Case Report—Spondylolisthesis with Incarcerated Nerve Root One of the patients who obtained no relief from the use of a brace was E S, male, age 56 For three months following an automobile accident in 1936 he complained of low back and sciatic pain on

the left side. The sciatica disappeared spontaneously and he had nothing more than mild stiffness and soreness of the low back until October, 1942, when he noted a gradual onset of sciatic pain on the right side, which was constant and severe, aggravated by standing or by stooping but always relieved by lying down.

When the patient was first seen in March, 1943, the sciatic pain was severe enough to cause him to limp. There was no trunk list, the lumbar curve was normal and tenderness was present in the midline over the spinous process of the fifth lumbar vertebra. The sciatic pain could be aggravated or reproduced by bending movements and straight leg-raising. Reflexes at the knee and ankle were normal and there was no muscular weakness. Roentgenograms revealed a narrow lumbosacral disk, bilateral neural arch defects and spondylolisthesis, Grade I.

The patient was referred to the Department of Neurosurgery where the diagnosis, "disease of the fifth lumbar disk with compression of nerve root," was made by Dr. Dean H. Echols.

The patient was fitted with a brace, which he wore for three months without relief. He returned in May, 1943, at which time exploration of the spine was decided upon. Doctor Echols stated that he found the spinous process and lamina of the fifth lumbar vertebra loose and not connected with the body. Exposure was obtained by nibbling away the right lamina of the fifth and small portions of the laminae of the fourth lumbar and first sacral vertebrae. The first sacral nerve root was observed to leave the dural sac at an unusually low level. In order to expose the fifth lumbar nerve root it was necessary to use a chisel to remove the bone from the intervertebral foramen in which the nerve was incarcerated. It was finally exposed enough so that it could be lifted with a hook and pulled posteriorly. The remainder of Doctor Echols' operative note read: "At the end of the operation the fifth lumbar and first sacral nerves were fully exposed and freed. The fourth and fifth disks were not actually inspected. The fifth vertebra was dislocated anteriorly as shown by roentgen ray and the posterior lip of the first sacral vertebra produced the only intraspinal mass."

The postoperative course was without incident and the patient obtained immediate relief from the sciatica. Six months later he wrote that he had neither back pain nor sciatic pain, although he is extremely active.

This case proves that sciatic pain may be due to incarceration of the nerve root in proliferated bone in or about the foramen. It is evident, therefore, that protrusions from the intervertebral disk may not be the sole cause of sciatic symptoms. In cases such as the one reported it is unlikely that the sciatic pain would be relieved in either case by spinal fusion alone or by conservative treatment. This suggests that when spondylolisthesis is associated with sciatic pain and roentgenograms reveal a narrow lumbosacral disk with marginal hypertrophic changes, the nerve root should be explored and decompressed when necessary.

This review suggests the following considerations for speculation:

(1) Low back symptoms observed in patients with spondylolysis or spondylolisthesis are probably due to narrowing of the intervertebral disk and arthritic changes in the lumbosacral articulation rather than to progressive displacement of the spinal column with consequent drag upon the supporting ligaments.

(2) Symptoms produced by lumbosacral arthritis, especially in middle-aged persons not engaged in heavy laboring occupations can usually be adequately relieved by braces, corsets, physical therapy and postural exercises.

(3) Younger patients with similar symptoms producing greater dis-

ability may require operative treatment but it probably would be sufficient to fuse the lumbosacral articulation alone instead of attempting to bridge from the third lumbar vertebra to the sacrum with a bone graft

(4) When sciatic pain is associated with spondylolisthesis, the nerve root should be explored and decompressed, either by liberating it from bony incarceration or by removal of a protruded intervertebral disk

(5) It seems possible, from a theoretic viewpoint, that in certain cases the symptoms might best be relieved by removal of the attached neural arch and the inferior articular processes. Liberation of the nerve roots without fusion of the articulation or bridging of the defect with a bone graft should, of course, be supplemented by postural exercises and low back supports

SUMMARY AND CONCLUSION

Fifty-nine cases of spondylolysis and spondylolisthesis have been reviewed from the viewpoint of diagnosis and treatment. This analysis suggests that probably a large percentage of patients with spondylolisthesis can be relieved by conservative measures and relief of symptoms in the remainder can be obtained by a simplified operation

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DISCUSSION—DR FRANK P. STRICKLER, Louisville, Ky. We are now seeing quite a few of these unfortunate patients who have had their nuclei pulposi, or disks, lifted. I do not know all about spines and low back pain, and I am equally confident that no one else has all the information on this subject. This problem has not been solved to date.

I would like to ask Doctor Dandy about some cases I have seen who have submitted to a number of operations—anywhere from two to five in some instances. I recall one woman who started with the removal of the fifth nucleus pulposus and progressed through a series extending up to the second lumbar. These operations were not all performed in the "Bush League" either. She had five operations in all—a most unusual patient! If removal of nuclei pulposi, or disks, cures these patients, she should be the most cured patient in the world, but this woman still has all her symptoms. She is a surgical derelict, her back looks as though a flock of woodpeckers and termites had worked on her and she had been topped off by a blast from a French "75."

Now let me tell you a little bedtime story to illustrate the point that all these cases are not what they seem to be. I was recently called in consultation to see a fairly

well-to-do lady who had low back pain. This patient had traveled around the country and had seen several neurosurgeons who had advised her to have an operation for the removal of the fifth nucleus pulposus, or disk, but for some reason she was not "sold" on the operation. I am a little old-fashioned, and I still believe that spine cases should have a carefully taken history, physical examination and the best of roentgenograms. In taking this lady's history I noted that her breath was reeking with liquor. I called her husband into an adjoining room and asked him how much liquor his wife was drinking daily. He said "Oh, about a quart and a half a day." Now, I am from Kentucky, but I believe that a quart and a half is a little too much for the daily consumption of any one woman. I advised her family doctor to get this woman off her liquor. He finally did get her straightened out, after having one sweet time with her. The results were that her back cleared up completely and she has had no more low back pain, she has been well now for more than a year. Had that patient had a disk operation during her alcoholic saturation period, some surgeon would have had a very interesting time during her postoperative convalescence. As I have said, I do not know all about low back pain, so you can make your own diagnosis in this case.

In closing, let me say there must be more common sense used in treating these patients.

DR ERNEST SACHS, St Louis, Mo. I would like to confine my remarks particularly to the presentation of Doctor Dandy. To listen to him, one would think the entire problem had not only been settled but was extremely simple. Those of us who have been interested in this subject and have had disks themselves, know it is not quite 98 per cent cures as he claims. In a recent article in the *ANNALS OF SURGERY* he says that diagnosis can now be made solely on the history of low back pain plus sciatica. It is not as simple as that, because there are other conditions which may give pain in the back, and although it may be true that pain in the back with sciatica may be due most frequently to dislocation of the disk, that is by no means the only cause. Spondylolisthesis, congenital defects, spinal tumors *etc.* must be considered. As Doctor Magnuson pointed out, a considerable number of patients with pain in the back and down the leg do not have a dislocated disk.

One of the most serious things, to my mind, is the statement made by Doctor Dandy in the above-mentioned article, and elsewhere, although he did not mention it tonight, that two-thirds of the cases that have these symptoms are due to a hidden disk. A hidden disk, as he illustrated very beautifully, is something anyone can produce if they cut the crucial ligament and curette out a little material. I always feel if I operate and do not get a good-sized disk that I have not reached the bottom of the trouble. I have seen some of these cases come back after months and years, one after seven years. I quite agree with him that one should not use contrast media, I quite agree that the spinal puncture ordinary should not be done.

I believe there is a wave of enthusiasm flooding the country and leading to operation for one of these so-called disks, and the operation itself may cause partial incapacity. Within the past two months I have had the opportunity of going to a postgraduate meeting in the West, just where I cannot mention for obvious reasons. I met the Commanding Officer who said they were discharging a number of men who had been operated upon for this reason and who were incapacitated for army work, that of course does not mean incapacitated for ordinary civilian work.

Doctor Dandy makes the statement that frequently the postoperative symptoms and signs are due to hypertrophied ligamentum flavum and that that is merely a self-satisfying explanation for negative findings. I believe it will not be so long before the term "ligamentum flavum" may be replaced by the phrase "hidden disk."

DR WILLIAM A. BOYD, Columbia, S. C. Far be it from me to pit my judgment against that of Doctor Dandy in the treatment of ruptured disk. However, I have seen a number of patients who supposedly had had ruptured intervertebral disks and had been operated upon, not only at Johns Hopkins, or elsewhere, but also in my own Clinic when we felt the symptoms justified the diagnosis, yet after operation, the backache and sciatica continued. I think we must consider these cases more carefully and not get into a rut where we feel that every man with a backache or a pain in the leg when he sneezes has a ruptured disk. There are many other causes, as Doctor Magnuson has told you.

Just a word about Doctor Caldwell's paper. I do not think it is necessary to have

a complete displacement of the spine to make the diagnosis of spondylolisthesis. We have all seen patients on whom roentgenograms were taken standing and in the lateral plane, where no displacement of the spine was seen, yet after they start working back-ache comes on. I think we can consider many of these as cases of instability of the lumbosacral junction, or potential spondylolisthesis. I have had many patients with no evidence of anatomic displacement but all the symptoms of lumbosacral strain, and when a spinal fusion is done they get well. Let us not let our imagination run away with the idea that everyone has a ruptured intervertebral disk, or that everyone has a spondylolisthesis, but take each individual as he comes, find out what is the cause of his discomfort and disability, and treat him accordingly.

DR CHARLES S VENABLE, San Antonio, Texas. I am discussing the papers of Doctor Dandy and Doctor Magnuson jointly. I think there was a period, before there was this attempted definite diagnosis as described by both essayists, in which we had to make up our minds whether we would do a fusion or a decompression. In some instances, if we guessed right, we did a fusion and did well, in some instances we guessed wrong and got into a mess.

In the period of decompression we thought the thickened ligamentum flavum and the changed condition of the ligaments interspinously had to do with the pathology, so we did a decompression and the patient got well, so we proceeded to digress from fusions. As Doctor Caldwell said, frequently we were not able to differentiate these from spondylolisthesis, which I think is true today.

Then we came to the period around 1936, when somebody found a thing called a nucleus—a displaced disk. That was the period in which lipiodol and other funny things were injected into the spinal canal. I did some of these and many did badly, an operation was needed to remove the new pathology—lipiodol. So then we came along to the period in which it is specific that we must find a disk. Doctor Dandy told us two years ago that all low back pain plus sciatica was due to a ruptured disk. That was a very dangerous pronouncement to make. I question the wisdom of that and I question the physical findings.

I am going to digress and say that decompression, as we have gone along, has been clinically the answer in a large percentage of cases. As an illustration, take the Indian who never wore shoes and never had a corn. After he wore shoes and got an exostosis which was rubbed on by the shoe, he got a corn, and when he quit shoes he got rid of his corn. I am going to mention one patient, a young man, age 20, who came in because of a painful left sacro-iliac joint that was very severe. The reason I know it was the left sacro-iliac is because when he was eight years old he had had a nonsuppurative nontuberculous osteitis, with complete fusion of the right sacro-iliac and we all know that if you have a fusion of one the other will be painful. I fused the left, in a year and a half he wrote that he had been getting alone fine, but now had to ride fences from 16 to 18 hours a day because he had not been able to get labor, and would that make any difference because he had developed pain in the back and thigh, I said it made a lot of difference.

He came in a few months later with a very severe low back pain and an exquisitely painful right sciatic nerve, with pain in the heel, *etc*. A diagnosis of herniated disk was made, and on exploration a nucleus the size of a pea was found anteriorly and to the right, between the fourth and fifth lumbar. With the cord pulled to one side this was easily visible, so two other surgeons working in other rooms were called to see it as I proposed deliberately not to remove it, but to close the wound in the usual way. The lamina of the fourth and fifth vertebrae had been removed. This man left the hospital on the tenth day without any artificial support nor did he have either low back or sciatic pain. He is now back ranching and riding in New Mexico.

The Negro only cuts a piece out of the shoe for relief of a corn. I say to you that if there is pathology of the cartilage between the bodies you do not cure it by scraping it off with a chisel, harm may be done by that, while I believe it is the decompression that brings the relief.

DR WALTER E DANDY, Baltimore, Md (closing). I appreciate Doctor Venable's frank comment. Two years ago when I said that the diagnosis was almost an absolute one, I realized that it was a very startling statement and one that would provide incredulity. I can only say that I would not dare make a statement of that kind.

without incontrovertible evidence to sustain it. Two years later that statement stands *absolutely*. It is a perfectly simple, easy diagnosis, and needs no spinal injections. I certainly have no desire to make something sound easy if it is not.

Doctor Strickler's patient who had five disks removed is about as good an example as you would want of poor, bungling surgery. All I need say is—look at the surgeon who did it. I know full well how poor these results have been even in the best hands. Disks are recurring, sciaticas are recurring, backaches are recurring. But that need not be so if they are properly diagnosed and properly treated.

Doctor Sachs gave the impression that there was some discrepancy in what I said six months ago. I then said you could diagnose 95 per cent of cases by the history alone. I said tonight that you can diagnose 98 per cent with the history and the roentgenograms. You can diagnose at least 50 per cent by the roentgenograms alone—*viz*, by a narrowing of the intervertebral space, and this is pathognomonic of a defective disk. That is Nature's method of curing the disk, but it takes many, many years and may even then be unsuccessful, because the protrusion remains to cause the sciatica. I think you can tell by the history the difference between a large protruding disk and a concealed disk, they are fundamentally all the same but the large protruding disks have more continuous and more intense pain (sciatica) than the concealed ones. However, the treatment is precisely the same.

Although sufficient time has not passed to make a dogmatic statement concerning cures, I believe that when properly treated cures can be assured. I hold no brief for bad surgery.

DR PAUL B. MAGNUSON, Chicago (closing). One of my relatives once said to me "You are always positive, and sometimes right." We all have opinions based on our personal experience, and my experience over a period of 35 years of dealing with the subject of immediate interest has convinced me, just as firmly as Doctor Dandy is convinced that he is right, that he is wrong. We are not going to convert each other tonight, but I think we have at least brought one question before this audience for its judgment, whether any one of you would like to submit to an operation for pain in the back accompanied by sciatica, without having had a thorough examination, without considering any other factors that might contribute to the pain, and take a chance on getting well, or, whether you would like to have the diagnosis based upon a complete examination, and have the operation suggested afterward if necessary.

SYMPOSIUM ON CHEMOTHERAPY

A REPORT ON THE HEALING OF WOUNDS AS INFLUENCED BY THE USE OF THE SULFONAMIDES AND COTTON THREAD SUTURES*

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CHARLESTON, W. VA.

USE OF SULFONAMIDES IN OPERATIVE WOUNDS

A GREAT DEAL of animal experimental work has been carried out with regard to the effects of the sulfonamides in wounds. Perhaps the most notable series has been conducted by Varco who performed 250 experimental stomach operations on dogs, covering a period of four years. These dogs were killed and the results noted from time to time. It was observed that when a suture line involving a hollow viscus had been dusted with sulfanilamide crystals union had been much more certain. He noted that when sulfonamide crystals had been dusted along the suture line, in every case there was found an unusually heavy deposit of fibrin which had firmly sealed the serosal surfaces at each suture line. Elsewhere the peritoneum was smooth and glistening. With such a mechanism for inhibiting bacterial growth locally, normal postoperative healing promptly took place.

Bartlett and Jones,² after extended studies on the healing of sterile and infected wounds in guinea-pigs, found that the use of sulfanilamide in a wound did not reduce the tensile strength of the scar, also that maximal saturation of the tissues with ascorbic acid markedly aided in providing optimal tissue healing and resistance to infection.

Animal operative surgery carried out in contaminated wounds by Lord, and associates,³ showed that the most satisfactory healing of wounds and the greatest number of successful blood vessel anastomoses that were made in contaminated cases, resulted from the combined use of sulfathiazole orally and sulfanilamide locally after careful debridement had been done.

Paracelsus⁴ said that in the final analysis it is the mustering defensive forces of the body which repel the invader and repair the damage. Since the sulfonamids are bacteriostatic and are thus able, for a while at least, to restrain toxic activity it seems obvious that they should be used with the hope of lessening the incidence of wound infection.

Key⁵ expresses the opinion that the local implantation of sulfonamide powder in clean operative wounds is a safe procedure and definitely lowers the incidence of operative infections. He reports that in over 600 consecutive cases (elective operations) there were no toxic symptoms, except

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

fever, which occurred in about 5 per cent of the cases and may or may not have been caused by the drug. In these cases the total postoperative complications were three deaths, seven hematomas, one separation of wound margins, and four mild infections, two of which developed late. In the other cases the wounds healed in a normal manner without excessive scar formation and, in his opinion, the average period of hospitalization was shortened by the use of the drug. He uses sulfanilamide or sulfathiazole powder or crystals, or a mixture of the two drugs.

Loria⁶ in his analysis of 100 consecutive cases of gun shot wound of the abdomen treated operatively, states that 49 received chemotherapy and of these 18 per cent died, while of 51 cases treated without chemotherapy 51 per cent died.

Quoting from a recently published article by Evans and Hoover⁷ "In Doctor Bigger's clinic at the hospital of the Medical College of Virginia, sulfanilamide has been used locally in several thousand wounds since 1938. All of us there are now absolutely convinced of the wisdom of this treatment."

Not long after he began the use of sulfanilamide in wounds, Doctor Bigger, during a visit to Charleston, told us of his very satisfactory experiences with sulfanilamide. We began using it in operative and other wounds and later combined it with sulfathiazole. Our practice has been to use both sulfanilamide and sulfathiazole in all wounds whether contaminated or not. The amounts used usually have been small, from 1 to 3 Gm. in the average abdominal incision. In practice we have found that the crystalline forms of sulfanilamide and sulfathiazole are less likely to cake and are more soluble than either the powder or the granular form. It is believed that the crystalline forms, when used in serous cavities, as in the abdomen or chest, diffuse more readily and are less likely to promote the formation of adhesions than the powdered forms of these drugs. On the other hand, when the necessity to control oozing arises as in bleeding from bone, powdered sulfathiazole firmly pressed against the oozing point, will usually stop the bleeding in a short time and may take the place of bone wax very well. Sulfanilamide is usually completely absorbed from a wound inside of 48 hours whereas sulfathiazole, being more slowly soluble, may persist for several days.

When ecchymoses occur about an operative incision following the implantation of sulfa drugs in a wound they are usually due to the fact that too much of the drug was used. Our use of these drugs has been to sprinkle them lightly throughout the wound and to spread them smoothly and evenly over the wound surfaces. When used in moderation and evenly spread we have been unable to detect any actual delay in healing.

The editorial board of The American Academy of Orthopaedic Surgeons in a review of progress in orthopedic surgery for 1942 mention the observations of Bick and Pheasant⁸ which are to the effect that as long as small amounts of sulfanilamide compounds were used and also as long as the drug was implanted deeply in the wound that neither delay in healing nor delay in recovery of function of the joint was noted, that small doses were adequate.

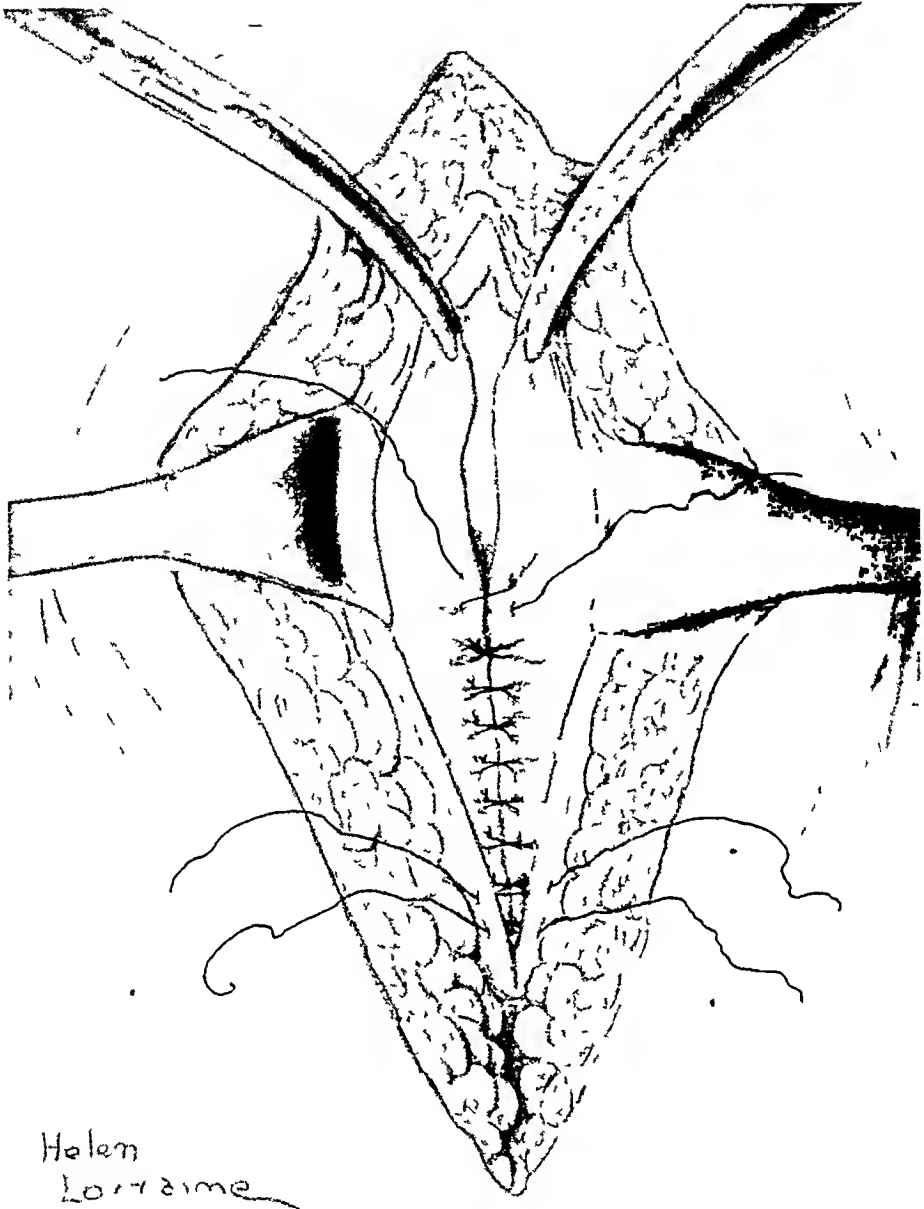


FIG. 1—Closure of peritoneum and aponeurosis

for the control of infection and did not cause reactions such as adhesions, fibrosis or other alterations in the joint. The editors further note that these conclusions confirm the observations now being made in hospitals of the armed forces all over the world.

In definitely contaminated abdominal cases we usually put sulfanilamide or sulfathiazole, as a rule not in excess of 6 or 8 Gm., in the abdominal cavity, placing both sulfanilamide and sulfathiazole in the operative wound as well. In chest wounds both the above mentioned drugs are used also. A moderate amount of sulfanilamide is routinely placed in all open wounds as soon as possible after admission to the hospital.

Our patients are given oral or intravenous sulfonamide medication either preoperatively or postoperatively as seems to be indicated, we feel that this is

in no wise incompatible with the local use of sulfanilamide compounds and that the two different methods can be made to supplement each other to the patient's advantage in many cases

THE USE OF COTTON THREAD SUTURES

In the search for new and better materials it seems that we not infrequently wander far afield when what is wanted is at our door

My attention was called to Dr Alton Ochsner's⁹ first report on the clinical use of cotton thread sutures soon after it appeared in the Journal of the American Medical Association for December 16, 1939. We began using that type of suture soon afterward and have used it exclusively since that time

Among the important articles that have been published advocating the use of cotton thread as suture material are those of Meade and Ochsner,¹⁰ Meade and Long,¹¹ Sparkman and Williams,¹² Hinton and Locaho,¹ Taylor,¹⁴ Nelson and Collins,¹⁵ also Thorek,¹⁶ Likewise Gage,¹⁷ Foss,¹⁸ Crile,¹⁹ Horsley²⁰ and others, have advocated the use of cotton thread sutures

Meade and Ochsner²¹ showed that while unsterilized cotton has not quite the tensile strength of silk of equivalent size, after sterilization of cotton by boiling, there is an 11 per cent increase in its tensile strength, compared with only 4 per cent increase in silk. In their experimental work on animals it was found that there were moderate inflammatory reactions in the cutaneous tissues about both plain and chromic catgut, the latter somewhat more pronounced than the former. The edema was much greater than that surrounding either silk or cotton sutures

They emphasize the disadvantages of catgut, in that the preservatives used in preparation of catgut are deterrents to wound healing, that they produce a local inflammatory reaction characterized by increased exudation bringing about what Gage²² has termed a wet-type of healing, whereas silk, linen and cotton produce but slight inflammatory reaction and result in a dry-type of healing associated with early fibroblastic proliferation

Meade and Long²³ hold to the technic laid down by Kocher,²⁴ and later

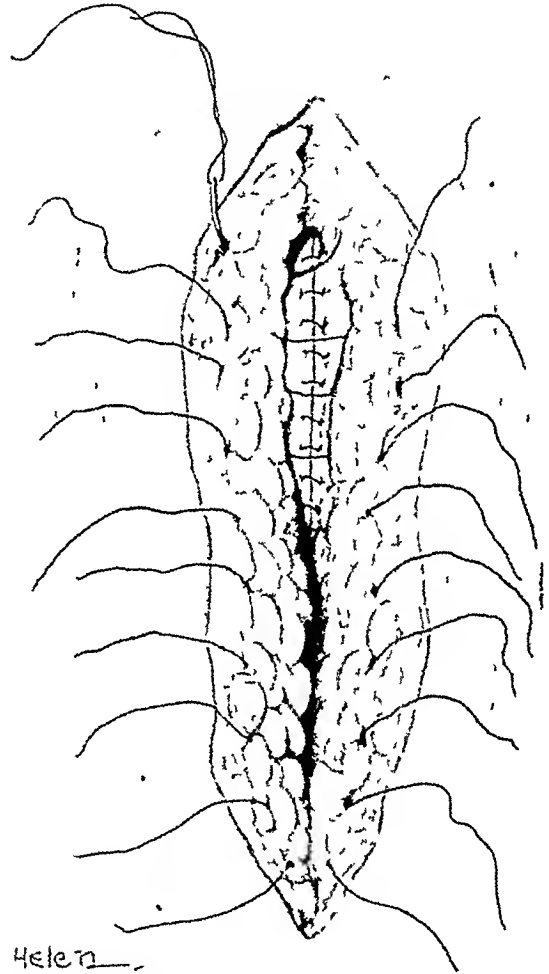


FIG 2—Closure of aponeurosis and subcutaneous fat

emphasized by Halsted,²⁵ in regard to the use of suture material, such as the use of finer suture material and the obliteration of dead space, also, that the combined use of absorbable and nonabsorbable material should be avoided. Apparently the compact structure of cotton prevents the ingrowth of tissue and lessens the incidence of suture sinuses which are rather common with the use of silk, particularly when used in superficial locations. It has long been known that the formation of sinuses incidental to the use of silk is much more frequent with continuous than with interrupted sutures, probably because infections are able to traverse the entire length of a wound along the tract formed by a continuous suture.

Microscopic Reactions—*Chromic Catgut* Marked leukocytic reaction extended deep in the muscle and fascia. *Plain Catgut* There were marked leukocytic and serum reactions in all the tissue layers without penetration

of the suture. *Fine Silk* Moderate leukocytic reaction extending from the surrounding tissue into the interstices of the suture, the fibers of which were considerably separated. Moderate amount of fibrin present. *Fine Cotton* Moderate leukocytic reaction in the surrounding tissue with an occasional leukocyte in the peripheral interstices of the suture. The reaction in the dermis was slightly greater than that in the muscle and fascia. Little evidence of serum. No fibrin.

When wounds were closed with cotton, tissue reaction was least and the appearance of the fibroblasts was earlier (fibroblastic proliferation was evident a little earlier in wounds closed with cotton than with silk). Whereas all inflammatory reaction had entirely subsided in 13 days in silk-closed wounds, inflammatory reaction had disappeared as early as ten days in wounds closed with cotton. It is generally assumed that non-absorbable sutures produce minimal tissue reaction and, therefore, are preferable to absorbable ones. This

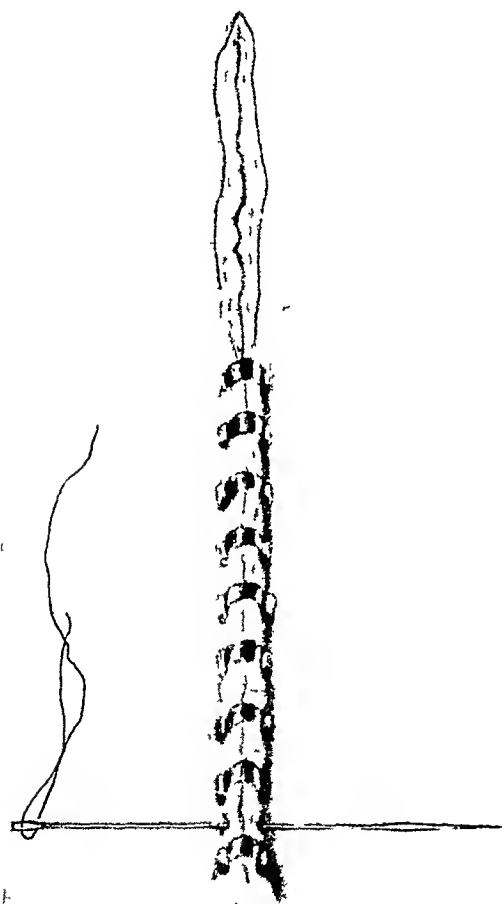


FIG 3—Closure of skin

assumption has been substantiated by investigations with silk and cotton. On the other hand, linen, which has been used surgically for a much longer period of time, produces a much greater reaction than either silk or cotton, and up until the fifth day produces almost as great a reaction as catgut. This continues to diminish until the end of the tenth day.

WOUND HEALING

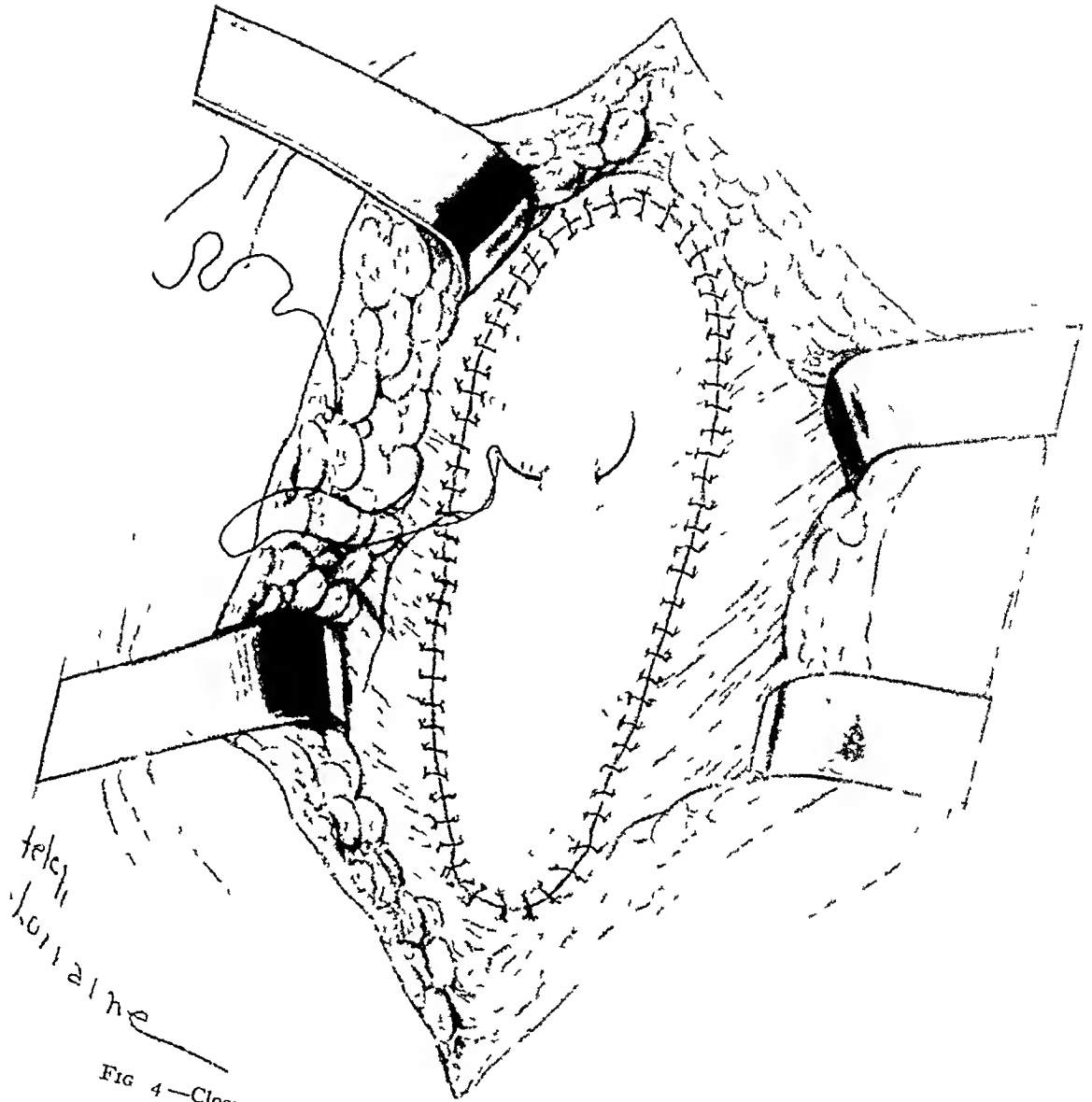


FIG 4—Closure of subcutaneous fat when cutis graft is used

Meade and Ochsner²⁶ recommend cotton as an inexpensive, pliable, easily sterilized suture material. Due to its high coefficient of friction, cotton is not likely to slip after the first throw of a square knot. Furthermore, it can be tied with reliable square knots. After implantation in a wound, catgut, silk, linen and cotton decrease in tensile strength in the order mentioned. They have graded suture materials with the following criteria in mind: Amount and persistence of leukocytic infiltration, amount of serum and fibrin, appearance time of fibroblasts, and the length of time necessary to produce final healing. Wounds sutured with cotton showed the least reaction and healed in a shorter length of time.

In the research department of Temple University Medical School extended studies have been made by Laige and his associates,²⁷ in regard to the relative values of suture materials. Their findings are that among ordinary suture materials the tolerance of the tissues to sutures is in accordance with the

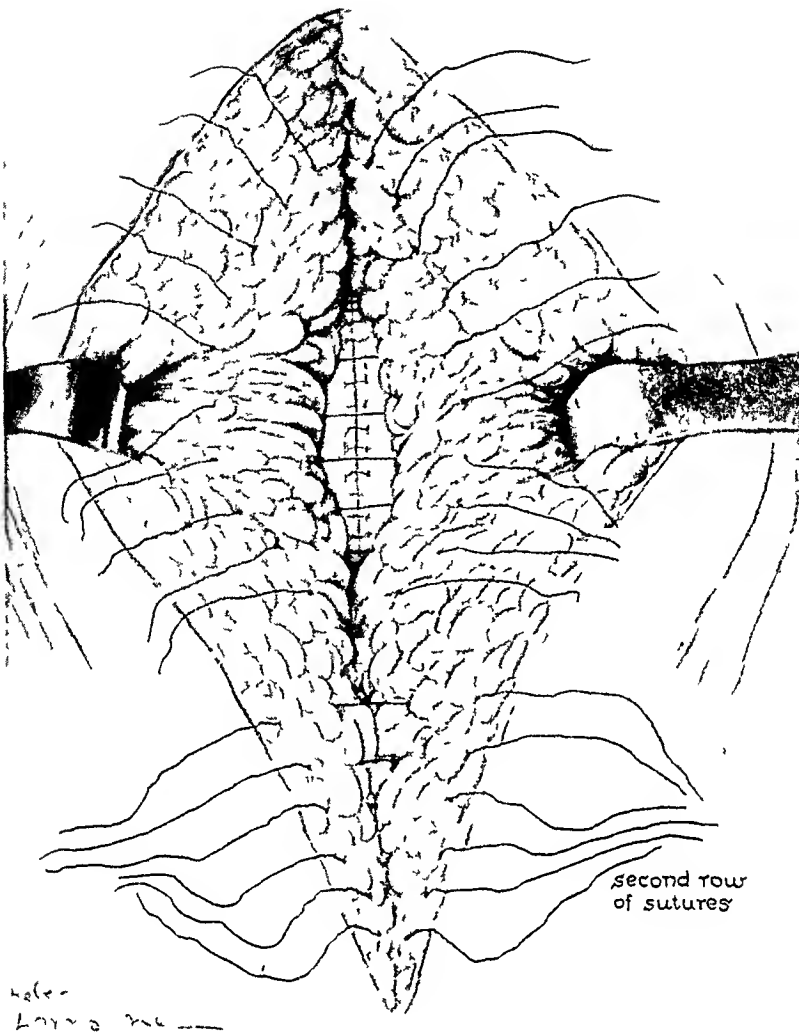


FIG 5—Closure of subcutaneous fat in very obese patient

following listing: Fine, stainless steel wire, cotton thread, silk, plastigut, nylon, and catgut. Quoting Halsted he says: "The merits of sutures should be based upon their reactivity in tissues, wound strength and ease with which they can be handled." He further states that sutures causing the least reaction facilitate wound healing by reducing the inflammatory changes incidental to healing. He also notes that catgut, which causes the greatest reaction, is still the suture of choice, but that the surgical trend of today is changing toward nonirritating types of suture.

Hinton and Localio²⁸ state that various objections have been raised against the use of catgut. Among the more important of these are difficulty of sterilization, allergic sensitivity, variable absorbability, deleterious effects of chemicals, such as the production of serum, delayed fibroblastic activity, and delayed wound healing. Other well-founded criticisms are increased incidence of wound infection, wound disruption, postoperative hernia and unreliability of the square knot tied with catgut. Silk is unquestionably an

excellent suture material. However, it has come into disrepute with some surgeons because slowly healing sinuses occur if infection develops. They state that cotton shows less tendency for tissue ingrowth between its fibers, and, hence, is less likely to produce sinuses in the presence of infection. Cotton, therefore, partially obviates some of the more serious objections to the use of nonabsorbable sutures.

Buxton and White²⁹ in their study of wound healing in 809 consecutive thoracoplasty stages performed on 195 patients from January, 1940, to January, 1942, closed the incisions with catgut in 538 cases and with silk in 271 cases. Of the thoracoplasty wounds closed with catgut 102 developed various abnormalities of wound healing, an incidence of 18.9 per cent, whereas only 19 or 7.0 per cent of the 271 wounds closed with silk developed some complication.

*Skin Preparation*³⁰—In preparation of the skin we have used iodine and alcohol.

After the peritoneal closure has been made most of our incisions have been irrigated with saline, with a view to the removal of at least some of the air-borne bacteria and other contamination.

Technic—Nelson and Collins³¹ have emphasized the need for greater exactness of technic, the avoidance of mass ligation with heavy suture material, *etc.*, also, the advantages of using fine cotton sutures such as Nos. 80 and 120, particularly for plastic work.

It has been observed from time to time that quite a few of the beginners in the use of cotton thread sutures in surgery are having the occasional formation of sinuses followed by the extrusion of sutures. These untoward happenings are almost always the result of improper technic, such as the use of sutures that are too heavy or the use of heavy sutures in the wrong location, *i.e.*, too near the skin, failure to close dead space over the heavier sutures, *etc.* In our work the parietal peritoneum and posterior fascia are routinely closed with Nos. 30 or 40 cotton thread carried through twice and tied. The aponeurosis is usually closed with size No. 30 interrupted sutures spaced not over one-quarter-inch apart, oftentimes less.

The closure of the fat layer of the abdominal wall over this aponeurotic suture line is particularly stressed. This closure is usually made with size No. 100 cotton thread sutures spaced about one-half-inch apart. A fairly deep bite into the fat is made on either side. Parallel sutures are placed and tied after all sutures are in. These sutures to a marked degree tend to prevent the development of a wide-spreading incisional scar. Skin clips, placed about one-quarter-inch apart, are used for the skin, interrupted cotton thread sutures, usually size No. 100, each one taking a comparatively light bite of skin, are placed between each two clips with a straight needle. The suture line is dusted with sulfanilamide crystals before a dressing is applied. The skin clips are usually removed on the second postoperative day and the interrupted sutures in from ten days to two weeks after operation.

In closing operative wounds, particularly in obese subjects and more

especially with reference to closure of wounds after the repair of incisional and other large herniae, it is of the greatest importance to close the wound in such a manner as to have the fascial suture line snugly covered with fat so as to obliterate dead space. In very obese patients, it may be necessary to close the fat in two or more layers, all with fine sutures. Fat heals perfectly when sutured in this manner.

Ligations inside the abdominal cavity with heavy ligatures, such as are at times used by many surgeons, particularly in such operations as hysterectomy or stomach resections, can be safely duplicated with heavy cotton thread. These ligatures are quickly glazed over by peritoneum and apparently do not cause trouble later on.

One of the greatest satisfactions in the use of cotton thread sutures is the fact that we are enabled to make a strong closure of an incision, mainly by the use of subcutaneous sutures. To me it has been a particular satisfaction to get away from the old tension sutures that included skin and aponeurosis. Better looking scars are now obtained and a greatly lowered incidence of wound disruption and postoperative hernia. As a further indication of the confidence we have in our abdominal wound closures, unless the patient is extremely ill we routinely try to get our patients out of bed at least twice each day beginning on the day following operation. They are encouraged to sit in an easy chair as long as they wish, to walk about the room, to the toilet, *etc*. This not only improves their morale but speeds up their recovery to a marked degree.

We have found cotton thread sutures of the finer sizes, *e g*, Nos. 80 to 100, to be very useful in cystocele and rectocele repairs, the closure of vesicovaginal fistulas and likewise to be very satisfactory in open anastomoses and various other types of gastro-intestinal surgery. Still finer sizes, like No. 120, are useful in dealing with plastic procedures about the eyelids, lips and face.

Doctor Ochsner³² has expressed the opinion that cotton thread is of particular value as suture and ligature material in the operation of thyroidectomy. Dr. Hugh Bailey³³ expresses the opinion that the use of this

TABLE I*

CLEAN WOUNDS USING COTTON THREAD SUTURES SULFANILAMIDE
SULFATHIAZOLE AND WOUND IRRIGATION

No. of Cases	No. of Infections	Percentage of Infections
1440	18	1.3%

TABLE II*

CONTAMINATED WOUNDS USING COTTON THREAD SUTURES
SULFANILAMIDE SULFATHIAZOLE AND WOUND IRRIGATION

No. of Cases	No. of Infections	Percentage of Infections
612	42	16%

* The cases listed have been compiled from the surgical services of Doctors Bankhead Banks, Hugh A. Bailey and myself. The writer wishes to acknowledge the excellent cooperation on the part of the surgical residents in the treatment of these cases and in the keeping of accurate records concerning wound healing.

material enables the surgeon to close many thyroidectomy incisions without drainage. It is the writer's firm conviction that cotton thread suture material, properly used, will give superior results in all types of surgery.

A brief summary of a consecutive series of major surgical operations done by myself and surgical associates during the past three years in which cotton thread sutures, sulfanilamide and sulfathiazole have been used is submitted (Tables I and II).

The general run of our surgical cases has been mainly abdominal and gynecologic, including hernia, incisional and inguinal types, all without recurrence so far as we have been able to determine, gastric and intestinal resections associated with several open anastomoses of the large bowel (through the courtesy of Sharp & Dohme the majority of these had the benefit of both preliminary and postoperative succinyl sulfathiazole), ulcer perforations, *etc*. Virtually none of the contaminated or other cases, excepting leaking gall-bladder cases, also a few toxic thyroid cases, have been drained. There have been six hematomas, one incisional hernia has been observed recently in one of our cases operated upon about one year ago (no doubt there are others but we have not been able to locate them), four wound disruptions—three of them contaminated cases—(one of these died several days after a secondary closure). The so-called anatomic types of incisions have been favored when practicable. The infections that occurred in the clean cases have been almost without exception of a delayed type, mild in character, and followed by satisfactory wound healing.

SUMMARY

As a result of extended clinical trial it is felt that wound healing is not interfered with by the conservative local use of the sulfonamides. In my opinion the use of sulfonamides in wounds gives the surgeon an increased assurance of a lowered incidence of operative infection, it is believed that most of the infections occurring in contaminated cases will be less severe than might otherwise have been expected.

A tabulation of results with regard to healing of wounds in which the sulfonamides and cotton thread sutures have been used is given. It has been found that when cotton suture material has been used in accordance with an approved silk technic the results have been very satisfactory, also, that with the use of fine cotton sutures contaminated wounds usually heal without subsequent sinus formation.

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DISCUSSION—DR JOHN E CANNADAY, Charleston, W Va Speaking of stainless steel wire sutures, this type of suture is unquestionably more troublesome to place than the other types of permanent sutures in general use by surgeons. It very definitely constitutes a foreign body to a far greater degree than either cotton or silk. Apparently well authenticated reports would indicate that even buried stainless steel wire sutures may at times be the cause of considerable annoyance to the patient.

In regard to our various friends who want to stick to catgut, they do so out of habit or because it is the easiest way even though the ultimate results may not be all that might be desired. I have had considerable experience with catgut, silk, linen, but was never entirely satisfied with any one of them. I have found cotton to be a very satisfactory suture. I will admit that it takes more time to suture a wound with cotton than with catgut.

THE CHEMOTHERAPY OF INTRACRANIAL INFECTIONS*

OBSERVATIONS ON THE USE OF THE SULFONAMIDES AND OF PENICILLIN UNDER VARIOUS EXPERIMENTAL INTRACRANIAL CONDITIONS

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DURING the past two years, nearly 700 experiments dealing with the effects of various chemotherapeutic agents upon the normal brain and in intracranial infections have been carried out in our laboratory, by Drs William F Meacham, Ralph Angelucci, Edmund Benz, Thomas J Holbrook and myself. A great many have been, or are being, reported in detail elsewhere. Some have proved fruitless. In all of these experiments, determinations of drug levels in blood and cerebrospinal fluid, cultures of blood and cerebrospinal fluid, histologic study by as many as eight staining technics, as well as clinical observations, have been made. It is our purpose in this paper to summarize some of the significant findings in these studies but space will not permit inclusion of many pertinent observations.

A—THE SULFONAMIDES

I—The Effects of the Sulfonamides when Applied to the Normal Dog's Brain^{1,2} Sulfanilamide, sulfathiazole and sulfadiazine were placed upon the cerebral cortex in varying amounts. The drugs proved invariably to be irritating, but no serious clinical effects were observed except with sulfathiazole. The latter produced violent and often fatal convulsive seizures. The frequency and severity of the attacks were roughly proportional to the dose of the drug. All of the drugs produced marked irritative and destructive phenomena in the cerebrum and its membranes. Fibrosis in the meninges, acute leptomeningitis, subcortical hemorrhage, gliosis, metamorphosis of microglia and degeneration of neurones were the most striking changes. These alterations were greatest with sulfathiazole and least marked with sulfanilamide.

A microcrystalline suspension of sulfathiazole, when injected into the

* The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Vanderbilt University.

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The sulfathiazole was supplied by E. R. Squibb and Sons, New Brunswick, New Jersey, the sulfadiazine by Lederle Laboratories, Inc., Pearl River, New York, and the microcrystalline sulfathiazole and sulfadiazine by Smith, Kline and French, Philadelphia. The penicillin was furnished by E. R. Squibb and Sons, and by Charles Pfizer, Inc., New York, on recommendation of the Committee on Chemotherapeutic and other Agents of the National Research Council.

cisterna magna, resulted in rapidly fatal convulsions in nearly all animals. A similar preparation of sulfadiazine produced convulsions in only one of six dogs.

It was concluded that sulfathiazole should never be placed in contact with the brain and that sulfanilamide and sulfadiazine should be employed, if at all, only in small amounts and with a full realization of their irritative effects.

II—Experimental Staphylococcal Abscesses A strain of hemolytic *Staphylococcus aureus* known to be virulent for dogs was prepared in sealed ampoules which were then kept in a freezing chamber in order to provide cultures of identical virulence for all experiments. Intracerebral infections were produced in three different ways. By the injection of staphylococci in agar, by the insertion of a gelatin capsule containing the organisms, and by injection of organisms into a previously injected mass of sodium ricinoleate (by the method of Markley³).

The experiments were carried out in groups of 12 and were equally divided between treated and untreated animals. Various groups were treated with sulfathiazole or sulfadiazine administered orally at eight-hour intervals in such dosage as to maintain an adequate therapeutic blood level of the drug in all treated animals.

Although abscesses were produced in the majority of animals, the results were not invariably consistent. Furthermore, abscesses which became well encapsulated did not usually terminate fatally. When abscesses ruptured into the ventricle or the subarachnoid space, fatal results were, in reality, attributable to meningitis rather than to the abscess. For all of these reasons, mortality rates in these experiments are not statistically significant.

Careful histologic study failed to reveal any significant difference in cellular reactions between the treated and untreated animals. The incidence of encapsulation was about the same in the two groups.

III—Staphylococcal Meningitis Injection of the same strain of staphylococci into the cisterna magna invariably produced a fulminating meningitis which usually* terminated fatally within eight hours, in control experiments.

The effects of oral administration of sulfathiazole were studied in 32 experiments, of oral administration of sulfadiazine in 36 experiments, and of intracisternal injection of a suspension of microcrystalline sulfadiazine in 36 experiments.

Therapy with sulfathiazole did not significantly influence the mortality rate in the three groups of experiments in which it was given. This was not surprising, in view of the relatively low concentration of sulfathiazole in the cerebrospinal fluid which it is possible to obtain by oral administration.²

On the other hand, in two of three groups, oral sulfadiazine therapy resulted in a definitely lower mortality rate as well as a longer survival time in experiments terminating fatally. In one group of 12 experiments three of the six treated dogs recovered and only one died within eight hours, whereas

* Even in these experiments, there was an occasional recovery or longer survival period.

five of the six control animals died within eight hours and the remaining dog died after 24 hours

Intracisternal therapy with microcrystalline sulfadiazine seemed to be very slightly beneficial in two groups of experiments and possibly slightly harmful in a third group. At necropsy, a firm mass of the drug was found completely filling the cisterna magna and covering most of the base of the brain. None of the animals had convulsions. It is not believed that this method of therapy is clinically beneficial or safe.

IV—Open Cerebral Wounds Contaminated with Staphylococci In an effort to simulate the early treatment of wartime cerebral wounds, other groups of experiments were done in which a button of bone was removed, the underlying cortex traumatized and contaminated with staphylococci, and left exposed for a period of one to two hours. Treatment was then instituted with local application of sulfathiazole or sulfadiazine (with or without subsequent systemic therapy) and the wound closed. Again experiments were done in groups of ten or 12, of which half were treated and half untreated.

Local application of sulfathiazole did not seem to produce beneficial results. Mortality rates, survival time (in fatal experiments), healing of soft tissue wounds and histologic findings were essentially the same in treated and untreated groups.

On the other hand, local application of sulfadiazine resulted in a lower mortality rate in the treated animals. The beneficial effects of treatment were externally evident in the prompt primary healing of the wounds in the treated groups, whereas the wounds of the untreated animals almost invariably disrupted and drained for long periods.

When local sulfadiazine therapy was supplemented by subsequent oral administration of the drug, the beneficial results were more striking. Fourteen of 18 treated dogs recovered, as compared with nine of 18 untreated animals, and the survival time in fatal experiments was longer when treatment was given in most cases.

V—Pneumococcal Meningitis A virulent strain of Type I pneumococcus was prepared and frozen, as with the staphylococci previously described. Meningitis was produced by injection of saline suspensions of the organisms into the cisterna magna. The meningitis thus produced usually ran a slower course than did the staphylococcal meningitis. In control experiments, a thick, viscid, purulent exudate was produced and the infection usually terminated fatally in four or five days.

The effects of sulfadiazine administered orally have been determined in 12 experiments and others are in progress. So far, results indicate that sulfadiazine is distinctly beneficial.

B-PENICILLIN

I—Staphylococcal Meningitis ⁴ It has been shown by Rammelkamp and Keefer^{5, 6} that penicillin, when administered intravenously appears in the

cerebrospinal fluid in only very minute quantities. This was supported by the disappointing results of our experiments in which intravenous penicillin therapy had no significant effect in experimental staphylococcal meningitis.

For this reason, we tried the effects of injection of penicillin directly into the cerebrospinal fluid. In the normal animals, the drug produces a transitory irritative effect which may be quite severe with large doses, but which subsides rapidly without significant local or systemic injury. This observation was also made by Rammelkamp and Keefer^{5, 6} in human subjects.

In experimental staphylococcal meningitis, such intrathecal penicillin therapy produced strikingly beneficial effects. Nine of the 16 treated animals survived, as contrasted with only one survival in 15 untreated dogs. These results were obtained with doses of penicillin now known to be far smaller than the optimum dosage.

II—Staphylococcal Abscesses These lesions have been produced as previously described and have been treated with penicillin administered intrathecally and intravenously. Results are equivocal. They seem to indicate that the treatment diminishes the likelihood of development of meningitis, but has little or no effect upon encapsulated infections. Additional experiments are in progress.

III—Open Wounds Contaminated with Staphylococci In this type of wound, produced as already described, penicillin has been employed locally as a spray. About one cubic centimeter of a solution containing 1000 Oxford units per cubic centimeter was sprayed upon the wound one to two hours after contamination. In some experiments additional intrathecal and intravenous treatment with penicillin was employed.

Early results of these experiments seem to indicate that local application of penicillin in high concentration to traumatized cerebral tissue may actually be harmful. The mortality rate was much higher in the treated animals. Additional experiments and histologic studies (as yet not complete) are necessary before final conclusions will be permissible. *A priori*, one might expect the acidity of the solution of penicillin* to be quite irritating.

IV—Pneumococcal Meningitis† In this type of infection, due to the same strain of Type I pneumococcus as that previously employed, intrathecal penicillin, in only moderate doses,† produced markedly beneficial results. The mortality rate was lower and survival time in fatal experiments was longer in the treated groups. The cerebrospinal fluid, grossly purulent in all control animals, was strikingly clear, with relatively low cell count, in most of the treated dogs.

Some of the fatal results among the treated animals were found to be due to pneumococcal pneumonia. The mortality rate was still further reduced when intravenous as well as intrathecal administration of penicillin was employed.

* pH 5.2 to 6.5, depending on the concentration.

† 100 to 200 units twice daily in dogs weighing seven to ten kilograms.

SUMMARY

The results of approximately 700 experiments have been summarized. The following significant findings have been emphasized:

- 1 Sulfanilamide, sulfadiazine, and sulfathiazole were irritating to the normal dog's brain, increasingly in the order given.
- 2 Sulfathiazole very frequently produced severe convulsions when applied to the brain, and should never be so employed.
- 3 Sulfanilamide and sulfadiazine, in small doses, may safely be used in the intracranial chamber.
- 4 Experimental cerebral staphylococcal abscesses were benefitted by oral sulfonamide therapy only insofar as their effects on secondary meningitis were beneficial.
- 5 Experimental staphylococcal meningitis was markedly benefitted by oral therapy with sulfadiazine but not with sulfathiazole.
- 6 Open wounds contaminated with staphylococci were benefitted by local application of sulfadiazine, but not of sulfathiazole.
- 7 Penicillin produced transitory meningeal irritation when injected intrathecally but may safely be given by that route in relatively large doses.
- 8 Intravenous penicillin therapy was ineffective in experimental staphylococcal meningitis but intrathecal penicillin therapy was markedly beneficial.
- 9 Penicillin, in strong concentration, may be harmful when applied directly to the brain.
- 10 Intrathecal penicillin therapy was of marked benefit in experimental pneumococcal meningitis.

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DISCUSSION—DR WAITER E DANDY, Baltimore, Md Doctor Pilcher's paper is important and very timely It is a fine example of the value of scientific approach to the solution of the problem, instead of floundering through trial and error With the magic results one obtains from the use of the sulfa drugs and penicillin, one might be ready to accept the thought that the same would hold true for all expressions of infections It is my experience from the clinical side, just as it is Doctor Pilcher's in his animal experiments that none of these drugs have any appreciable effect when the infection becomes walled-off Meningitis will clear in 24 hours, but the drug does not reach an encapsulated abscess

Of particular interest is the adverse effect of the various drugs on brain tissue when treating open wounds This is, of course, all important to the Army and Navy at the present time Without these timely experiments by Doctor Pilcher we might well have floundered through, expecting that all these drugs would have only beneficial effects when used locally, and without serious sequelae Precision is attainable only by test through experiments I see no flaw in Doctor Pilcher's experimental studies The results should be applied by the Army and Navy at once There is an old maxim—"Be not the first to accept the new nor be the last to throw the old aside" That holds here Lives and serious after-effects can be spared by the experimental approach, of which this is a beautiful example

MAJOR H J WARTHEM, JR, Richmond, Va I would like to comment on one thing Doctor Cannaday emphasized the importance of adapting the technique of the surgeon to nonabsorbable sutures when these are used This is not always realized by neophytes They have read about the advantages of silk or cotton or steel wire, and they either do not read the entire article or it does not emphasize sufficiently that they cannot adopt nonabsorbable sutures without changing their former catgut technique I think this is particularly true with the younger surgeons who enter the service They feel they have broken with the old civilian practice and entering the service gives them an opportunity to break with some of the methods formerly used by them Inasmuch as there has been so much in the literature in the past few years regarding cotton, silk and synthetic suture material, they feel it is a good opportunity to start using it I am afraid many neglected to change their technique when they changed their suture material This has meant that some draining sinuses have resulted and the nonabsorbable material must be extruded in many cases before the sinus heals This is true of silk, cotton or steel wire, just as it is of any other foreign material I am not saying this as a critic of cotton or silk, for I have used nonabsorbable sutures for the past 16 years, but I try to follow the dictums of Halsted, which are just as true now as they were 50 years ago You cannot use cotton or silk with the old catgut technique For this reason I was particularly pleased to hear Doctor Cannaday stress this point

DR CHARLES C GREEN, Houston, Texas The last time I appeared before you a lot of you thought I was joking, but I am not joking now Shortly after World War I there was a very popular play in New York—"Fifty Million Frenchmen Can't Be Wrong"—and I think that applies in the use of nonabsorbable sutures Too many men have used catgut and get good results to give up to a minority Ochsner, and some others say they are not progressive surgeons, but Ochsner has not had as much experience as I have, because I have lived a long time and I did not do as Doctor Dandy said—"Don't be the first to accept the new or the last to discard the old" I accepted the new and got into trouble, and I am back with the old catgut technique and I feel I get the best results that way

With regard to the use of the sulfonamides It has not been mentioned, but remember that sulfonamide is the most soluble of the sulfonamides in body tissue Many of us used sulfathiazole when it was at the height of popularity, with the result that later we found encapsulated crystals That will not happen with sulfonamide, and for that reason I feel it is good to use it as local treatment because it is soluble and will have its effect

One more statement about sutures I cannot see why, unless it is an economic problem they should use cotton instead of linen We are told we cannot use silk because of protein reaction, and I accept that But you can tie linen much more easily than flimsy cotton when it gets wet I really cannot see how it can be a permanent suture

They say it absorbs, but I have had patients coming in with silk in them for years I used it especially in hernia operations and I have picked things looking like mosquitoes out of the wound for months and months I know Doctor Al is one of the best surgeons in America and I have seen him use little bits of silk in doing a pneumonectomy, and I would be scared to do that One time when he was using little bits of silk he said—"What would you use?" and I said—"No 3 chromic catgut"

DR I A BIGGER, Richmond, Va So far as I know, the first person in Richmond to use the sulfonamides locally was the late Dr Joseph Geisinger, a Fellow of this Association I think that was in 1937 or 1938 I bring this out because Doctor Cannaday was kind enough to mention my name in this connection Though not responsible for this method of using the drugs, I am convinced that the sulfonamides are effective when used locally in other parts of the body than the central nervous system As Doctor Cannaday pointed out, the powder or crystals should be well distributed and not used in too large amounts in any area of a wound A mixture of sulfanilamide and sulfathiazole is probably best because sulfathiazole tends to cake when used alone, and sulfanilamide is not effective against staphylococci One must not use these drugs as a substitute for proper surgical measures in the treatment of contaminated wounds but as an adjunct to those measures I think there is danger that younger surgeons may become careless in the management of contaminated wounds, depending upon the sulfa drugs to prevent infection If this occurs they are almost certain to get into trouble

I would like to stress the importance of the administration of the drug by mouth or vein 24 to 48 hours following the local application, and continuing for from five days to a week These drugs when used only locally will, as a rule, prevent the development of fulminating infections, but infections may develop subsequently coming on after two weeks or even later

DR BARNEY BROOKS, Nashville, Tenn I believe those discussing the use of the sulfa drugs in wounds should clearly state what sort of wounds they have in mind I know of no evidence which has been disclosed which indicates the desirability of putting any antiseptic or bactericidal drug in a presumably clean operative wound On the other hand, there is a great deal of evidence in Doctor Pilcher's paper that the sulfa drugs produce damage to healthy tissues

DR JOSEPH E J KING, New York City I think Doctor Pilcher, and his coworkers are to be congratulated I should like to ask him two questions The first, has he injected or instilled sulfanilamide solution or penicillin directly into a brain abscess, and, second, have any cases of brain abscess recovered by so doing without operation for abscess?

DR WM H PRIOLEAU, Charleston, S C A consideration of wound healing is not complete without some reference to the dressing In this regard I would like to call attention to the fact that besides protecting the wound from contamination, an important but frequently neglected function of the dressing is that of wound splinting or soft tissue immobilization A firmly applied voluminous elastic dressing serves to obliterate dead space, reduce exudation and capillary oozing, and also to hold firmly approximated the wound surfaces, making possible more ready union This is particularly well demonstrated in the dressing of a skin graft While of definite value in all clean wounds it is especially so in such as thyroidectomy and amputation wounds where the raw surface is unduly large Rubber sponge incorporated in the dressing serves this purpose well Dressing a wound in this manner effectively protects it from the development of complications

DR FRANK K BOLAND, Atlanta, Ga I prefer sulfanilamide locally, and sulfathiazole internally, in infected or potentially infected wounds I am also coming to like cotton sutures I wish to show the slide of a skin suture I use in a large number of cases After the operation the patient is not so much interested in the pathology we have uncovered as she is in how much it is going to hurt to take out the stitches Her visitors have told her how much it will hurt For this reason I have tried to evolve a method which will produce little pain Dermal is used and no knots are tied, instead

I use a little lead perforated bead, such as is used in the obstetrical department to put around the baby's neck. The stitch is put in to evert the skin edge, if the incision is long it is done in sections. The bead is crushed here and suture made, then about the middle of the line of suture I put in an extra loop, the object of which is to enable one to pick up the suture and cut it. If this is not done, sometimes there is difficulty in finding the middle of the suture, because of swelling of the skin. This is lifted up slightly and nipped, and usually the ends can be pulled out easily. If it sticks a little I cut it and do not remove it for 24 hours. The patient is surprised and also disappointed. While she is looking forward to the pain she is expecting, the one stitch is out.

DR ALTON OCHSNER, New Orleans, La. I beg your indulgence for discussing another paper this morning, but since my No. 3 catgut, lariat-throwing friend from Texas has asked for it, I think it is necessary to give the reason why cotton and silk are preferable to linen. I felt at one time as Doctor Green does that linen should be the ideal procedure since Pagenstecher linen is advocated as a suture for ophthalmic surgery. In the investigation which Doctor Meade and I made, however, we found that linen produced almost as much reaction as did catgut, and it is for this reason that it should not be used.

Concerning the use of cotton, I have often made the statement that if I were told that I could use cotton in only one type of case I would choose to use it in the grossly contaminated abdominal wound. This statement is contrary to all the opinions concerning the use of nonabsorbable sutures, but the opinion is based upon our experience with cotton. Several years ago on our service at the Charity Hospital, we studied the incidence of complications in clean and contaminated wounds which had been closed by one of three suture materials—cotton, silk and catgut. This study was continued over a period of six months. Whereas there was not a great deal of difference in the clean wounds, there was considerable difference in the contaminated wounds. Those contaminated wounds which were closed with catgut all became infected. In the wounds closed with silk, 30 per cent healed by primary intention without any infection and 70 per cent became infected, whereas in the cotton-closed wounds, 48 per cent healed by primary intention and 52 per cent became infected. If one closes a grossly contaminated wound with catgut, wound disruption or herniation is likely to occur, as infection occurs in every instance. In the presence of infection, wound healing is definitely interfered with and fibroplasia does not become complete until the infection has subsided. Also, because of infection there is rapid absorption and digestion of the catgut so that there is a very definite period of time when nothing holds the wound edges except wound exudate. If, however, a contaminated wound is closed with cotton, according to our experience, one can expect primary healing without any evidence of infection in 48 per cent of instances. In the 52 per cent of cases in which infection does occur, there will be the same degree of interference with wound healing and fibroplasia will not be complete until the infection has completely subsided. In the meantime, however, the cotton holds the wound edges together so that wound rupture or herniation does not occur. In most of the cases which become infected even though cotton is present in the wound, healing occurs without the discharge of a single suture. In some instances a suture will become discharged, but this is a relatively cheap price to pay for the prevention of wound rupture and subsequent herniation. I prefer the use of cotton, because I think it is the ideal suture material available at the present time.

Incidentally, the cost is of interest, although this is not the reason I prefer it. We have estimated that the average cost per operation when catgut was used was \$1.19, when silk was used, and in all fairness to silk it must be stated that this was surgical silk, it was \$0.93, when cotton was used, which was purchased from that exclusive surgical supply house, Woolworth's, the cost was 1¼ cent. We estimated that at the Charity Hospital if everyone used catgut one year and then limited his use to cotton the next, there would be an annual saving of more than \$9,000.

Doctor Horsley asked about the use of malleable steel. Malleable steel produces no reaction, but is somewhat more difficult to use and is radiopaque. I believe that cotton has all the advantages that malleable steel has without these two disadvantages.

DR ALBERT O. SINGLETON, Galveston, Texas. It does little good to get a suture discussion going in a medical meeting, because everybody goes away of the same

opinion as when he came I cannot refrain from stating that most of the trouble complained of is with wounds in the abdomen I have contended for a long time that those who are having a lot of trouble with abdominal wounds are using unanatomic incisions If more respect for the anatomy of the abdominal wall is kept in mind, and less thought for the suture material, difficulties will be lessened If one cuts tissues across the line of tension, he will look for a long time to find proper suture material By substituting muscle and fascial splitting incisions for the old vertical incisions it will make suture material a less serious problem Circulation must be present for union of the tissues to occur If it is necessary to use much tension to hold the surfaces together there will be interference with circulation Therefore, I wish to make a plea for the serious regard for the anatomy of the abdominal wall as the solution for most suture material difficulties

DR. JOHN E. CANNADAY, Charleston, W. Va. (closing) Speaking of stainless steel wire sutures, the wife of a physician in our state had a vesicovaginal fistula repaired with steel wire sutures She went home apparently entirely well, but later a local urologist removed from time to time a total of 30 or more stainless steel sutures through the urethra

In regard to our various friends who want to stick to catgut, they do so out of habit or because it is the easiest way even though the ultimate results may not be all that might be desired I have had considerable experience with catgut, silk and linen, but was never entirely satisfied I have found cotton a very satisfactory suture I will admit that it takes more time to suture a wound with cotton than with catgut

DR. COBB PILCHER, Nashville, Tenn. (closing) I would like to thank Doctor Dandy for his very kind remarks In answer to Doctor Green, or in connection with what he said, I am in full agreement that sulfonilamide is still a drug with a great deal of usefulness, not only because it is more highly soluble, but also because it is less irritating than any of the other sulfonamides

Doctor King's question with regard to injecting drugs directly into an abscess cavity is beyond the scope of our work at present We have not done this and I do not believe it is feasible under the experimental conditions I have reported

CLINICAL AND LABORATORY EXPERIENCES WITH SUCCINYL SULFATHIAZOLE^{*}

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THE PROGRESSIVE IMPROVEMENT in mortality rates in large bowel surgery in recent years has paralleled the general improvement in mortality rates in all types of surgery. Although there have been of course specific technical innovations in various surgical fields that have been partially responsible for the generally lowered death rate of surgical operation, the major share of this decline has been due to a greater understanding of, and care for the patient in whom disease exists. The recognition, measurement and replacement of water, carbohydrate, protein, electrolyte vitamin and hemoglobin deficiencies and the general measures against spreading infection offered by chemotherapeutic resources are paramount in altering the degree of surgical risk. In each surgical field there are both general and specific technical measures that have particular importance.

In the field of large bowel surgery, the specific measures of chief importance have been directed against the risk of infection, both in the peritoneum and in the abdominal wall. In addition to aseptic technics of anastomosis, they have consisted of three major methods: (1) Stage operation, (2) attempts to decrease the bulk of bowel content and (3) attempts to alter or decrease the number of the organisms in the fecal stream. Before the introduction of the first effective "intestinal antiseptic" by Firor and Poth the third method has been based by certain surgeons on the principle that the pathogenic organisms in the bowel are largely proteolytic and that they can be decreased in number by denying them a protein pabulum^{1, 2, 3, 4}. The so-called "colon preparation" diet consists of a nonresidue almost completely carbohydrate diet with vitamin supplements. With increasing knowledge of the rôle of protein in the surgical patient, it is obvious that this is by no means an adequate diet in the preparation of patients for major surgical procedures particularly of patients with gastro-intestinal lesions who may already have depleted protein reserves from preceding relative protein starvation. It is also an exceedingly dull diet and, therefore has a definite psychologic disadvantage. When first sulfanilylguanidine and later succinyl sulfathiazole were made available through the reports of Firor, and others^{5, 6, 7, 11} it occurred to us that the new more direct method of attack on intestinal bacteria might offer the opportunity for providing a better balanced and more palatable diet to

^{*} Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La

patients approaching operations on the colon and rectum without at the same time discarding the supposed advantage of the older technic. In the present study in addition to specific data bearing on this point, we present confirmation of Firoz and Poth's general observations on succinyl sulfathiazole,^{8, 9, 11} and the clinical results in a small series of cases of operation on the large bowel in which the drug has been applied.

METHODS

Stool Culture—Specimens of stool, either fresh or promptly refrigerated after evacuation, were weighed and emulsified in appropriate dilutions. Plates of eosin-methylene blue agar were inoculated both by pouring and streaking and the number of colonies of *B. coli* and *B. aerogenes* were counted after adequate incubation. From this number in a known dilution, the number of colonies per gram of fresh stool could be calculated. This result was expressed in a logarithmic curve. These two organisms were chosen since they present distinctive colonies on the medium employed and offer an index of effect on organisms susceptible to succinyl sulfathiazole.

Blood Concentration—The concentration of free and combined succinyl sulfathiazole in the blood, was determined by the method of Bratton and Marshall.¹⁰

Urine Output—The amount of succinyl sulfathiazole in 24-hour specimens of urine was calculated in the same manner.

Diets—Three types of diet were employed in various studies, namely: (1) Regular hospital diet; (2) A high carbohydrate, high protein, low residue diet with vitamin supplement; (3) The "colon preparation" diet consisting of clear liquids and stick candy, also with vitamin supplement.

RESULTS

Laboratory Studies—Four healthy individuals, hospitalized for fracture or other disease not related to the gastro-intestinal tract, were first studied in an attempt to determine a base level of concentration of *B. coli* and *B. aerogenes* in the stools. It early became apparent that the variations from day to day are enormous, as shown during the control periods in the two cases presented in Chart 1. For instance, one patient on a regular diet showed a decline in the number of these organisms within a 48-hour period from nearly 10^{10} per gram of stool to 10^7 , a thousandfold difference. In spite of this fact, it was thought that perhaps an even greater decrease might occur following the administration of the "colon preparation" diet. Two cases were, therefore, placed on this diet for seven days, without apparent result (Chart 1). In neither case did the stool count fall as low as it had in the course of daily variations while on the regular hospital diet. Although the results in these two cases do not disprove earlier experimental work on animals and man^{1, 2, 3, 4} they suggest that the effect of a low protein diet on the bacterial pattern of the stool must be uncertain within the limits of time available for the preparation of patients for surgery of the colon.

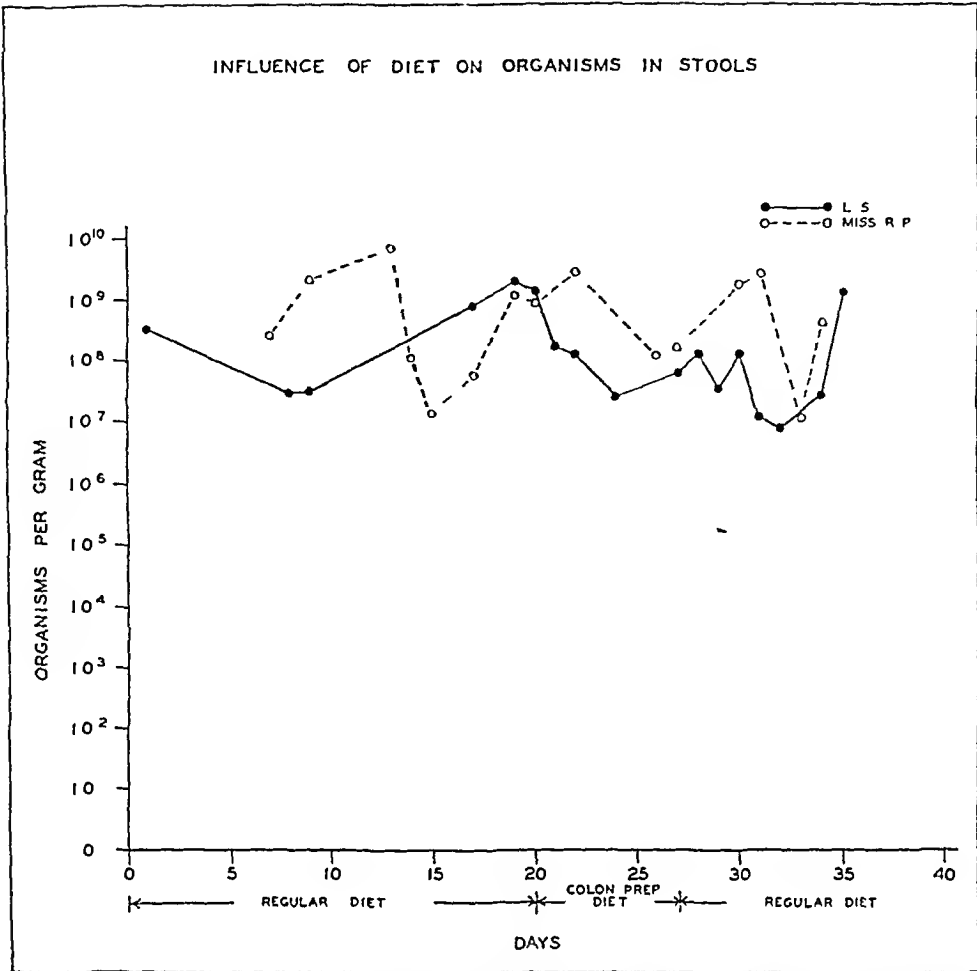


CHART 1—Counts of *B. coli* and *B. aerogenes* in stools of two patients on regular and 'colon preparation' diets. The curves are expressed logarithmically. Note that during the week of 'colon preparation' diet the stool counts did not fall as low as they did on regular diet. Note also that the variations on both diets are extreme.

The much more dramatic results of the administration of succinyl sulfathiazole as previously reported^{8, 9, 11} led to a different approach. Sixteen patients, ten of whom had large bowel lesions and six of whom had none, were studied before and following the administration of succinyl sulfathiazole in the usual dosage.¹² In all cases there was a prompt drop within six days in the number of *B. coli* and *B. aerogenes* from a level in the order of millions or billions per gram of stool to less than 100, and in some cases to zero, even when the undiluted stool was cultured. The average time of reaching the level of 100 colonies or less was 4.8 days. When the cases that received the clear liquid and sugar diet were compared with those that received adequate protein, no significant difference in the rate or completeness of disappearance of the organisms occurred (Chart 2). The patients with protein in the diet actually present a curve of more rapid decline than those without, if this relatively slight difference can be explained, the reason may

* The succinyl sulfathiazole employed in the earlier portion of this study was furnished by courtesy of Sharp and Dohme.

SUCCINYL SULFATHIAZOLE

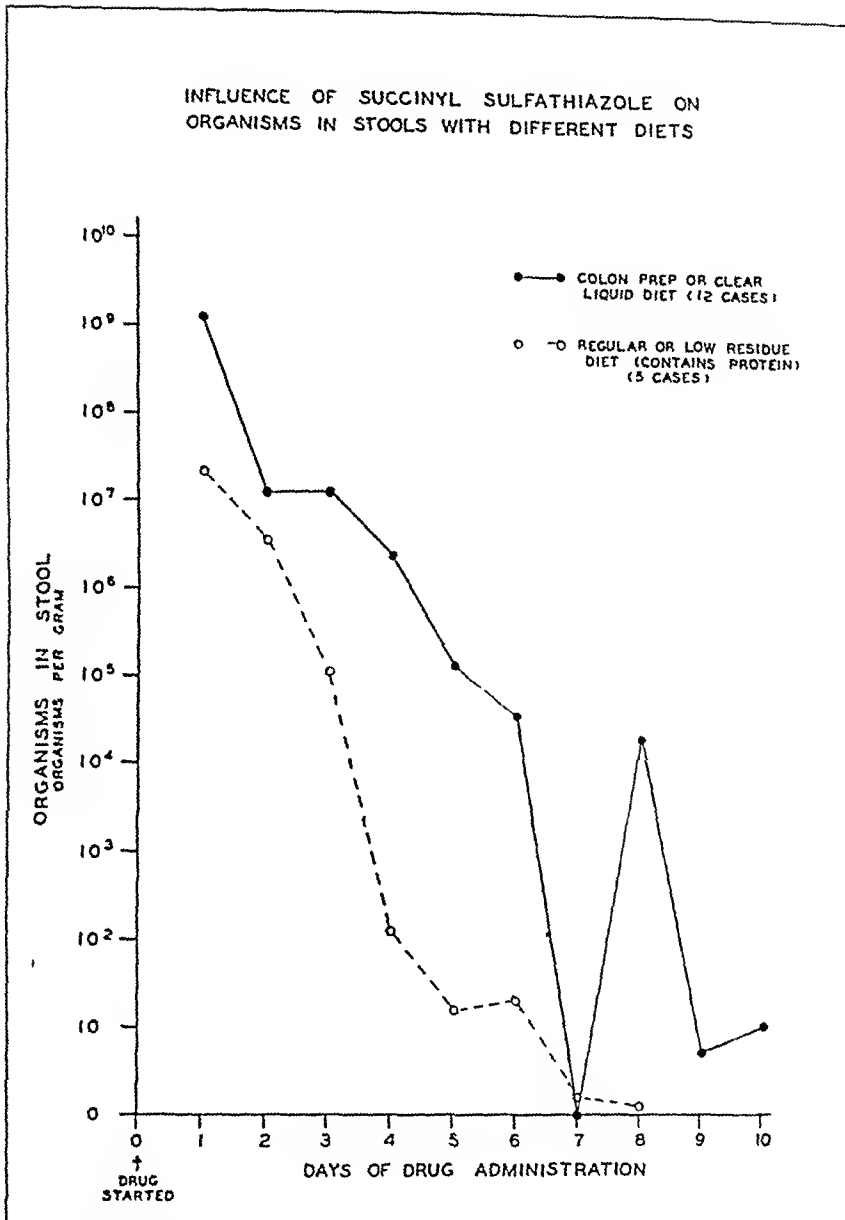


CHART 2—Average counts of *B. coli* and *B. aerogenes* in stools of seventeen patients receiving succinyl sulfathiazole. Five of these patients were on "colon preparation" diet and twelve on regular or low residue diet containing adequate protein. One case received the drug for only three days and is, therefore, not included in the results of complete treatment recorded in sixteen cases in the text. Note that there is no significant difference between patients receiving differing diets.

lie in the fact that most of the patients on the low protein diet had large bowel lesions, usually ulcerated.

In 15 cases the blood concentration of the drug was studied every two or three days. In five cases, only a trace of succinyl sulfathiazole was present in the blood. In only one case did the blood level ever rise above 3 mg per 100 cc. In that instance the concentration on one day was 5.9 mg per 100 cc, falling to 2 mg on the following day in spite of continued administration of the drug.

The total amount of succinyl sulfathiazole excreted in the urine was followed daily in 17 patients. The average amount excreted was 5.4 per cent of the amount ingested. The lowest amount was 1.3 per cent and the highest 11.1 per cent.

All patients receiving succinyl sulfathiazole both during the above experimental studies, and since, have been carefully watched for toxic manifestations as demonstrated in the blood picture, the urine, the temperature and pulse curve, the skin, and the psyche. The drug has been given to well over 45 individuals. In this number the only unfavorable occurrence was a hemorrhagic skin eruption which was seen in a patient who had previously received sulfathiazole. The rash did not progress while continuing the administration and cleared up promptly when the drug was withheld.

Clinical Cases—Succinyl sulfathiazole has been given to 36 patients in preparation for operations in which the large bowel was divided or anastomosed at the primary operation. Several cases of exploratory celiotomy, first-stage colostomy, or other procedures not entailing possible contamination from the bowel lumen were prepared for operation by this method but are not included in the present summary. Sixteen of the cases had a low residue diet with adequate protein, 20 were on clear liquids and sugar. All had vitamin supplementation. In 24 cases the operation was carried out by aseptic methods, 12 cases had known peritoneal contamination either from preexisting infection, accidental perforation of the bowel, or open anastomosis.

Three of the 36 cases died in the hospital, a gross mortality of 8.3 per cent. In only one case, however, could the death be ascribed to failure of succinyl sulfathiazole, the corrected mortality is, therefore, 2.8 per cent. One patient, age 58, died of thrombosis of the middle cerebral artery on the twelfth day after combined abdominoperineal resection of the rectum for carcinoma. Postmortem examination revealed a cleanly healed wound and no peritonitis. A second patient, a woman, age 44, suffering from postoperative fecal fistula was operated upon as a last resort in an attempt to overcome rapidly progressive malnutrition. She was found to have multiple fistulae of the terminal ileum, cecum, and ascending colon with marked chronic peritonitis presenting granulation tissue. A right-sided one-stage resection was performed, with open anastomosis of the ileum to the transverse colon. She died on the fourth day. Postmortem examination showed no acute peritonitis. The wound was healing cleanly. Death was ascribed to malnutrition and terminal pneumonia. The death that may be blamed on succinyl sulfathiazole occurred also in an unfavorable preoperative risk, a man, age 71, with carcinoma of the cecum involving the adherent jejunum and presenting marked lymph node metastases. An aseptic ileocolostomy was performed after right-sided colectomy as well as an open end-to-end entero-enterostomy of the jejunum following resection of the diseased segment. This patient died on the eighth day. Postmortem revealed death to have resulted from lobular pneumonia with multiple small lung abscesses. Although the abdominal wound was healing cleanly, there was a localized area of fibrinopurulent peritonitis.

It should be noted that all three of the deaths occurred in the group that had had an adequate protein diet. More striking perhaps, is the observation that 15 of the 16 patients who had had this diet presented no evidence

of peritonitis except for the case already cited that had peritonitis before operation

Of the 36 cases, 35 lived long enough to determine the nature of wound healing. In these 35 cases only two abdominal wounds were infected. In the entire group of 36 there was no clinical evidence of acute local or general peritonitis and acute local peritonitis was found at postmortem in only the single case cited.

The average highest postoperative temperature in the 36 cases was 100.8° F. In the group with known contamination of the peritoneum the average highest temperature was 101.4° F, and in the group without known contamination 100.5° F. The average postoperative hospital stay for the series was 21.3 days. This is somewhat greater than it should be, since several patients stayed in the hospital for unrelated procedures, such as operation upon the prostate gland. Forty-two per cent of the patients were discharged within 14 days following operation.

DISCUSSION—These studies have confirmed Firor's and Poth's reports on the characteristics and behavior of succinyl sulfathiazole. The low absorption rate is indicated by the low blood levels and the small proportion of the ingested drug excreted by the kidney. The infrequency of unfavorable reactions has also been demonstrated. Furthermore, the incidence of infected wounds and of evidence of peritonitis even following known fecal contamination is satisfactorily small. Finally, the dramatic diminution of *B. coli* and *B. aerogenes* in the stool following ingestion of the drug has been amply shown.

It is our opinion that the use of succinyl sulfathiazole in large bowel surgery has permitted two desirable improvements in methods. In the first place, we believe that the effective reduction of susceptible organisms in the stool in the presence of a high protein diet makes permissible the employment of a balanced and palatable preoperative nutritional management. The clinical evidence does not support this opinion directly, since the number of clinical cases prepared with adequate diets is too small to be significant. If this conclusion is correct, then patients undergoing resections of the large bowel should, in the long run, be in better state to withstand operation and subsequent starvation and should have a more favorable metabolic background for wound healing.

The second advance that the drug has probably made possible is the disappearance of stage-operations in this clinic. Except for enterostomy or colostomy in the presence of acute obstruction, an operation that has itself diminished in incidence through the use of suction decompression, there have been at the University of Virginia Hospital no stage-operations for carcinoma of the large bowel in nearly two years. We do not hesitate to perform primary anastomosis under permissible anatomic conditions at any level of the large bowel and have seen no disasters as a result. The advantage of this change in technic is obvious. The avoidance of temporary fecal fistula, of the crushing of spurs, of hernia through the site of closed fistulae, of repeated anesthetic hazards and of delay between stages for spread of malignancy.

nancy, make a one-stage method a boon to both patient and surgeon. The saving of cost and of hospital bed space is an additional accomplishment.

That these two attainments are due to succinyl sulfathiazole must be recorded as an opinion only. It is necessary to point out that the use of other sulfa compounds, both generally and within the peritoneum, may play a part in the results. We have not attempted to isolate the influence of other sulfa therapy from the influence of succinyl sulfathiazole, partly because the cases are so few, and partly because the records unfortunately are not sufficiently complete. In most of our 36 cases sulfamidamide was implanted over peritoneal suture lines and in the abdominal wall. Without succinyl sulfathiazole, however, we would never have dared to do the things that we now successfully carry out.

In addition, it must be pointed out that except for the improvements in technic mentioned, we do not believe that succinyl sulfathiazole should be used to replace older and tried methods of preparation of the patient for large bowel surgery. It does not obviate careful selection of patient, anesthetic and procedure. It does not obviate a period of five days to a week of preoperative hospital care with adequate measures for the relief of dehydration, anemia, hypoproteinemia, obstruction, and the like. It does not obviate the need for cutting down the bulk of the stool by a low residue diet, and the immediate preoperative washing of the bowel by enema. It is an adjuvant to all these things. In our experience it has been a valuable adjuvant.

CONCLUSIONS

1 Succinyl sulfathiazole is absorbed from the bowel and excreted in the urine in relatively small amounts. The incidence of reactions is small.

2 Ingestion of the drug results in a dramatic reduction of *B. coli* and *B. aerogenes* in the stool in less than five days, in the absence or presence of ulcerative mucosal lesions.

3 This reduction occurs without relation to the nature of the accompanying diet.

4 In this Clinic the use of succinyl sulfathiazole has been associated with two changes in method: (a) The use of a preoperative low residue diet containing adequate protein, and (b) the avoidance under many circumstances of stage-operations.

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THE TREATMENT OF BURNS COMPLICATED BY FRACTURES OF THE EXTREMITIES*

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A 4 F T T C B T C NO 10

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THE EXTENSIVE USE of gasoline in modern warfare has greatly increased the incidence of burns. Flying and tank personnel are especially liable to this injury and the use of oil in the Navy subjects the sailor to the same hazard. When a burned patient also receives a fracture, the treatment of both conditions becomes more difficult. A review of the medical literature since the onset of World War II fails to show any reference to the treatment of these associated injuries.

In an effort to gather data on this subject a questionnaire was sent to a number of Army Air Fields. The replies indicated that while this combination of injuries was not uncommon the majority of these accidents resulted in death before medical aid could be given. A total of 12 patients who were successfully treated was reported. Despite the limited number of cases, it was felt that these, plus the helpful suggestions received from many sources could serve as the basis for a brief study of this condition.

This discussion will be divided into two parts. The first will deal with the patient who has received a burn and a fracture which do not involve the same anatomic region. This will permit a résumé of our present treatment of burns. The question as to which condition should be treated first will depend upon the nature and extent of the individual injuries. Fortunately this rarely will be a problem, for the initial general treatment is the same for both conditions.

Shock must be prevented or treated immediately. This is best accomplished by plasma in appropriate amounts. Pain is controlled by 16 or 32 milligrams of morphine. Chemotherapy, which is begun immediately, is indicated in both burns and compound fractures.

The local treatment of the fracture and the burn can be carried out simultaneously. A sterile dressing should be applied to exposed burned areas prior to moving the patient, and a similar dressing should be placed over the wound after inserting sulfanilamide crystals when a compound fracture is present. Fractures should be properly splinted before the patient is moved. Burned clothing should not be removed until the patient has reached a station which will permit the entire burn to be dressed under sterile conditions.

For the sake of clarity the recommended treatment for burns will be outlined first. The amount of plasma needed will depend upon the loss of fluid from the burned area plus the amount necessary to offset the associated secondary shock. The loss incident to the burn may be approxi-

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rated by following Berkow's¹ method of estimating the extent of the burned area, and giving 50 cc of plasma for each one per cent of body area involved. This would mean that a burn of ten per cent of the body surface would require 500 cc of plasma. This method makes no allowance for fluid loss into unburned body areas as a result of shock, and additional plasma would be needed to offset this. A hematocrit determination, on the other hand, would give an overall determination of the plasma needs, and by following Harkin's¹ rule 100 cc of plasma would be given for each point that the hematocrit exceeded 45.

Upon arrival at the hospital the patient should be taken to the operating room. Every sterile precaution should be followed that is observed in the course of a surgical operation. The surgeon should scrub for ten minutes before donning sterile gloves, and all participants including the patient, should be properly masked and gowned.

The local treatment will vary chiefly with regard to the extent of the debridement. The tendency recently has been to do a minimal debridement consistent with removal of devitalized epidermis and all adherent and adjacent potentially contaminated tissue. The circumstances under which the burn was received and the subsequent exposure to infection will enter into this decision. Cleansing with cotton swabs moistened with neutral soap and flushing with large amounts of sterile water or normal saline will suffice in most cases. Burned fragments of skin and adherent foreign material can be removed without anesthesia. The narcosis induced by the morphine should suffice. The excision of charred tissue will depend upon the area involved, the general condition of the patient and the need for a general anesthetic to correct associated fractures. Immediate skin grafting after excision has been advocated, but this should be confined to patients in excellent condition, with limited burns. A booster dose of tetanus toxoid should be given to all third degree burns and to burns of any degree that involve the region about the buttocks.

When the entire area has been cleansed it is covered by sterile petrolatum and a layer of fine-mesh gauze is applied. This is followed by several thicknesses of sterile wide-mesh gauze dressing which, in turn, is reinforced by a thick, evenly applied layer of machinist waste which should extend well beyond the margins of the burn. Compression is obtained by a snug elastic bandage which should be carried from the distal end of the extremity well beyond the upper limit of the burn. Boric acid ointment may be substituted for petrolatum should the latter not be available.

This method may have to be modified frequently in burns of the face and hands, a common site of injury in military personnel. Occlusive dressings about the eyes, nose, and mouth are rarely practicable for they become soiled quickly and act as a septic poultice. Infection in facial burns is especially undesirable, for not only is grafting delayed but the scars that follow infected burns are dense and lead to disfiguring contractures. After the initial cleansing, facial burns should be covered with boric acid ointment or sterile saline compresses. Evans and Hoover² have obtained excellent

results in this type of burn with 6 per cent sulfanilamide ointment in a fatty base. Careful and individual nursing is essential in these burns. The rôle of the nurse as a morale builder is nowhere better exemplified than in burns of the face.

Compression dressings are difficult to apply to burns about the hands. A débridement followed by saline compresses or soaks in an arm tub is frequently the best treatment. Active motion should be begun early. Flexion deformities should be corrected by application of a banjo splint with elastic traction attached to the finger nails. The majority of severe burns will require skin grafting, and this must be undertaken as early as possible to prevent contractures. Each case must be individualized and every step must be carried out under rigid aseptic technic. It is only by attention to innumerable details that a badly burned hand can be salvaged and an aviator returned to active duty.

The general treatment of a burned patient is equally important during the first few days. Blood pressure and hematocrit readings must be taken at frequent and regular intervals during the first 24 or 48 hours. A falling blood pressure or rising hematocrit should be combatted by an appropriate amount of plasma.

Sulfadiazine should be used prophylactically in all extensive burns. An initial dose of four grams should be given. One gram should be given every four hours if the urinary output is in excess of 1500 cc daily. The blood sulfa level must be determined daily during the acute phase of the burn. Fluids should be forced and the intake and output carefully recorded. A low intake or vomiting will require intravenous fluids. Determinations of the blood chemistry, especially the nitrogen and chloride values should be made daily for the first week. An increase in the nonprotein nitrogen will necessitate intravenous dextrose injections, and chloride depletion should be corrected by normal or hypertonic saline. The red cell count and hemoglobin should be checked every two days during the acute stage of the burn and at least once a week thereafter. Frequent whole blood transfusions, and a diet high in vitamins, especially C, B₁, B₂ and D, will overcome the anemia and promote epithelization.

The dressing should not be disturbed for ten days or two weeks unless infection is suspected. After removal of the contaminated outer wrappings the dressing should be soaked or moistened with saline for several hours to permit its removal without pain or damage to underlying granulations and epithelium. Sterile precautions must be observed. The condition of the wound will determine the subsequent treatment. In clean wounds with early granulations, a second application of petrolatum or boric acid ointment followed by a pressure dressing may be all that is necessary. This may remain for ten days or two weeks if the local and general condition of the patient remains satisfactory. If uncertainty exists, the burn should be dressed every two or three days. In the presence of infection, or if the area appears unhealthy, saline compresses or soaks should be substituted. Maceration of the skin responds to exposure to air for one or two hours daily. Scarlet

red ointment, by its stimulating and hygroscopic qualities, will often cause rapid epithelization when applied to a sluggish wound with scattered islands of epithelium arising from hair follicles. This ointment, if used sparingly, is also useful in toughening new and delicate skin.

The importance of early skin grafting in third degree burns is now generally appreciated. This can usually be undertaken by the fourth or fifth week. A clean granulating surface and the general condition of the patient are the determining factors. If the hemoglobin is below 75 per cent, whole blood transfusions should be given. Burns about the hands, face, and the flexor surfaces of joints should be given first consideration. Grafting of extensor surfaces and the trunk can wait until the above areas are covered. Exposed areas and flexor surfaces are best protected by thick split-grafts removed by the Padgett dermatome. These should measure about 0.012 inch in thickness. The grafts are sutured in place and a pressure dressing should be applied. A light plaster splint should be incorporated in dressings about joints. The small deep graft of Davis is an excellent general utility graft in burns of the trunk or extensor surfaces. These grafts are economical and survive well in infected areas. Small deep grafts should not be used about the face or hands for cosmetic reasons, and there is a greater likelihood of late contractures following their use.

The treatment of a simple fracture which does not underlie a burned area will differ but little from the treatment of a fracture unassociated with a burn. In general, an immediate reduction followed by a plaster encasement is most satisfactory. This will permit the patient to be turned freely in caring for the burn and avoids the danger of pulmonary complications or pressure sores from prolonged immobilization with traction. Some form of skeletal fixation in fracture of the femur is indicated in order to avoid a spica encasement and to permit ready handling of the patient. Shaar² has used external skeletal fixation by means of the Stader splint with excellent results in several cases of fractures associated with burns. External fixation by the Stader, Roger Anderson or Haynes method would appear to be the ideal treatment in cases unsuited for simple reduction and plaster encasement.

A theoretic and doubtless practical advantage in an occasional extensive burn is the availability of the fractured thigh as a possible donor site, if unencumbered by plaster or traction apparatus. The "hanging cast" method of treatment has proved useful in fractures of the humerus. The simplest method of fixation should be used in any fracture, for the mental hazard inherent in all burns would be accentuated by painful and awkward equipment. The treatment of a compound fracture does not differ from that followed in a patient without a burn.

A general anesthetic will usually be necessary in the reduction of fractures associated with burns. Sodium pentothal is especially useful in burns about the face.

This brings us to the treatment of fractures complicated by burns of the same part, in other words, burns of an arm or leg associated with a fracture of that limb. These injuries are more difficult to treat than those that have

just been discussed. Anterior and posterior plaster splints or a circular plaster encasement of the involved part proved satisfactory in several cases reported. A number of those who answered the questionnaire took occasion to point out the potential value in these injuries of a close fitting plaster of paris encasement, as advocated recently by Levenson and Lund,¹ for the treatment of burns uncomplicated by fractures. These authors treated 22 burned patients by the plaster method with satisfactory results. The burns involved the arms and hands in 28 instances and the legs in four cases. The method in brief is as follows. A layer of petrolatum gauze is carefully applied to the entire area. This is covered by four layers of sterile open-mesh gauze. Thin anterior and posterior plaster slabs are molded to the part and a few layers of rolled plaster completely encase the extremity from its distal end to several inches above the upper limit of the burn. The encasement is changed every 14 days until the burn is healed or the area is ready for grafting. The following advantages are claimed by Levenson and Lund. The early application of the encasement prevents swelling of the part and loss of plasma from the burned surface, capillary flow is increased with stimulation of the healing processes, the possibility of secondary infection is obviated, the method requires a minimum of material, it is comfortable to the patient and after care is greatly simplified.

This method holds great promise for the treatment of burns of the hands, forearm and legs complicated by fractures of the underlying bones. The burned area should be cleansed in the recommended manner before the fracture is reduced. The position should be checked roentgenologically, with especial care not to jeopardize the sterile technic. A good reduction is essential for the success of this method. This treatment could be followed also in compound fractures by combining with it the Orr method, which is based on the same principle of wound treatment. It would be wise however to modify the method in one respect until sufficient experience is obtained to prove or disprove the need for this safeguard. Despite the admonition of Levenson and Lund that the plaster must be closed at the lower end of the extremity, it would be far safer in these combined injuries with a deep as well as a superficial source of swelling, to leave a small opening at the distal end of the encasement to permit inspection of the circulation. An opening no larger than the cross-section of the fingers would hardly upset the fluid balance established by the remainder of the plaster encasement and it would determine whether the circulation was adequate.

The amount of dressing applied to the part depends upon the time that elapsed between the injury and the application of the encasement. The greater the interval the more abundant should be the dressing. The accuracy of the reduction of the fracture also determines the degree of subsequent swelling and this has to be considered in dressing and encasing the part.

This method lends itself well to the treatment of fractures of the leg and forearm. Fractures of the humerus and femur would require a different type of handling. In fractures of the humerus a compression dressing is applied to the entire hand, forearm and arm while reduction is accomplished

by the constant traction obtained from a superimposed 'hanging cast' Skeletal traction is, of necessity, the method of choice in the treatment of fractures of the shaft of the femur complicated by overlying burns. In most cases an unburned area about the leg or ankle will permit the insertion of skeletal traction through normal tissue. An occasional extensive burn will be encountered which will entail the passage of a pin or wire through a burned area. The likelihood of deep infection will be minimized by an intensive preliminary débridement at the site of insertion of the skeletal traction. The recommended compression dressing can then be applied to the burn. Three patients in this series with burns of the thigh and fractures of the underlying femur were treated successfully by skeletal traction. In one case it was necessary to insert a wire through burned tissue. Infection did not develop. In a fourth patient with a fracture of the femur and an overlying burn, traction was omitted and a marked shortening resulted.

The general principles governing the prevention of infection in wounds and burns, outlined recently by a committee of the National Research Council⁵ is of especial value in handling complicated wounds of this type. These measures include the segregation of burned patients, a uniform time and method of dressing the burns, a routine for sterilization of ward equipment and suggestions as to the application and removal of plaster encasements.

In closing, I should state that I realize the conclusions outlined in this paper are based upon relatively few cases and that their value is limited to a corresponding extent. There is a need, however, for more information on this difficult subject and if this presentation stimulates discussion its preparation will be justified.

The author wishes to express his appreciation to the following medical officers for aid in the preparation of this article: Lt Col Alfred R Shands, Jr, Orlando, Fla.; Lt Col I R Trimble, APO 927; Lt Col Harold H Hamilton, Westover Field, Mass.; Major Paul N Mutschmann, Biggs Field, Tex.; Major John E McDonald, S A A C C, San Antonio, Tex.; Major Bernard B Larsen, Travis Field, Wis.; Major Charles R Burbacher, Morrison Field, Fla.; Major Paul G Morrissey, Maxwell Field, Ala.; Major John A Martin, Randolph Field, Tex.; Major Foster L McMillan, Lowry Field; Major H J Veatch, Homestead AAF, Fla.; Capt Thomas B Keller, Salt Lake City AAB, Utah; Capt C D Brown, Peterson, AAF; Capt Louis C Olker, Douglas AAF, Ariz.; Capt Ralph F Spencer, Mitchel Field, N Y; Lt Gerald I Cetrul, Rosecrans Field, Mo.

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DISCUSSION—DR PAUL B MAGNUSON, Chicago, Ill. I feel that Doctor Warthen's paper is so important that it should not be allowed to pass without discussion of the terrifically complicated conditions he mentioned. If there is any place in surgery where one needs all the ingenuity he can muster, it is in these fractures complicated by burns.

Doctor Warthen spoke of putting wire through a burn, and it occurs to me that the point of insertion of the wire is very important. Ordinarily, in the femur, we put it in from the outside to the inside, which is the handiest method. However, in a case of this kind a little maneuvering might be in order, to start it on a clean surface, reversing the usual process and putting it through at a point where the skin can be prepared, and then bringing it out through the wound surface would reduce the hazard of infection materially. On these little details often depends the success of treatment in such complicated injuries, and the ultimate result is largely dependent on the ingenuity of the surgeon at the time the wound is originally or secondarily treated.

DR J M T FINNEY, Baltimore, Md. I have very little personal knowledge of the subject of Doctor Warthen's paper, but recently I have had occasion to talk to Captain Owsley of the Medical Corps of the Navy, who was successively surgeon on two large aircraft carriers in the South Pacific, one of which is no more. During that time they had a considerable number of compound fractures complicated by extensive burns. I have never served on a carrier, so I do not know much about it. He says their equipment is limited, and their knowledge of how to treat these cases was also limited at that time. Because of this, they tried to start with treating the fracture until they could get to a hospital, which was sometimes a period of several weeks. The standard procedure was to clean the surface of the burn, which usually involved the leg or arm with the compound fracture, apply liquid petroleum or vaselined gauze, then put on a tight plaster encasement and leave it. Much to his surprise, when the encasement was removed they found that the burns had healed, or were healing satisfactorily. As a result of this experience, under his direction at the present time this is the method of choice in cases of burns plus fractures. He said it is surprising even in third degree burns, from the standpoint of comfort of the patient, rapidity of healing, and satisfaction of the method of treatment.

DR ALTON OCHSNER, New Orleans, La. There is a recent contribution which you may not be familiar with because it appeared in the Public Health Reports. Rosenthal developed a technic for burning mice, which produced death in approximately 95 per cent of the cases. By the administration of mouth serum and albumen he was able to prolong the life of the mice somewhat, but by the administration of sodium chloride intraperitoneally 90 per cent of the mice could be saved.

Fox introduced this form of therapy in a group of patients at the Harlem Hospital. In approximately 50 severely burned patients receiving large quantities of sodium lactate solution by mouth, because it was impossible for the patients to drink much sodium chloride, very good results were obtained. Of the group, only one patient had plasma and this was a severely burned patient who received but one unit of plasma.

Rosenthal was able to show by means of radio-active sodium that the sodium in burned animals became fixed in the tissues, particularly in the normal and burned skin, in the muscle, and in the bone. Both in the humans and in the animals there was no excretion of sodium until about the thirteenth or fourteenth day. Rosenthal is of the opinion that the beneficial effect obtained by the administration of plasma in burns is due to the sodium content of the plasma.

MAJOR H J WARTHEN, JR, Richmond, Va. (closing) This paper should really have been prepared by a naval surgeon, rather than by a doctor in the Air Force. The cases that occur in the Navy are more likely to survive than those that occur in airplane accidents. Judging by the replies to the questionnaire I sent out, for every case reported that lived, five or six cases died immediately or within a few hours after the accident.

I was pleased to hear Doctor Finney's account of Captain Owsley's experience, because, fortunately, it coincides with our conclusions based on the limited number of cases we have had. I would leave a small opening at the end of the plaster when a plaster encasement is used for treatment of combined burns and fractures.

Doctor Magnuson mentioned that most of these pins can be placed through an unburned area. I think this is true. There should be some area from the knee downward that is uninvolved, particularly the ankle. In one patient in our series it was impossible to find a single unburned area in the ankle or leg that would permit passage of a pin, and in that case the surgeon cleaned up the area, passed the pin through the burn and no ill results occurred.

POSTOPERATIVE SALT INTOLERANCE*

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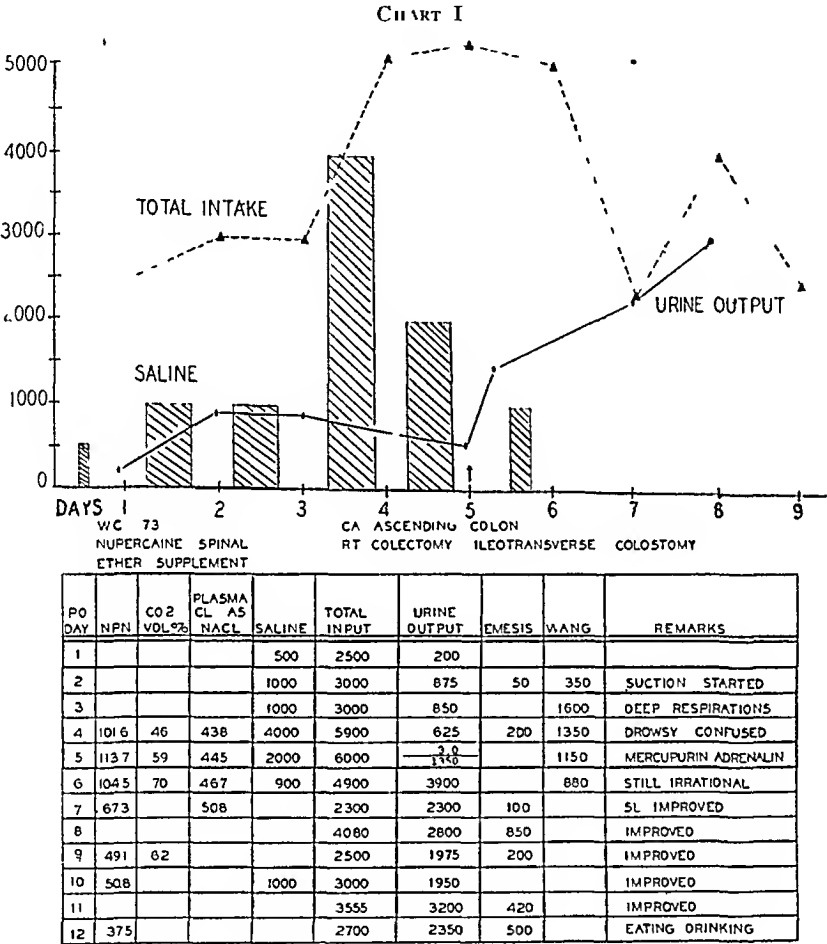
THE EXPERIENCE OF YEARS regarding the toxicity of isotonic sodium chloride solution has been forgotten. Trout and Evans urged caution in the use of isotonic saline solution over thirty years ago. The clinical experiments that Trout reported, although few in number, enabled him to draw conclusions that hold the essence of the whole problem. It seems appropriate then that Trout should be quoted (1) "Even we surgeons know of the wonderful improvement in some patients with nephritis when placed on a salt-free diet, and all of us realize there is a transient renal irritation or possibly a nephritis following the majority of anesthetics and infections. In seven cases in our series the following coincidence has been observed, a transient albuminuria remained in every specimen for two days after an anesthetic when using salt solution per rectum. Water was then substituted, and at the end of 24 hours the albumin had disappeared. At this time a return was made to salt solution, with the appearance of albumin and a few hyaline casts in from six to 24 hours. Patients were then placed on a limited salt diet, and the urine in every case promptly returned to normal and remained so until discharged from the hospital. In none of these cases was there any edema. (2) In this entire series, in both the salt and water cases, there have only been 121 who complained of being thirsty, and of this number 112 of them were salt cases. There were 27, or over one-fourth of these cases, who complained of tasting salt when they had absolutely no way of knowing that they were being given saline by rectum, and the solution being prepared so as to be 0.6 to 0.9 per cent sodium chloride. Furthermore, the water cases have taken one-third more fluid by rectum than the salt cases, and the latter have required nearly twice as much water by mouth to relieve thirst. (3) It is true sodium chloride is the least toxic of the group of similar metal chlorides, but even at that it is a poison to all people when given in large doses, and occasionally very toxic in small doses to a certain class of cases, and we believe this peculiarity is apt to be present in patients whose resisting powers are lowered by operations and infections."

The purpose of this discussion is to retract the so-called clinical rule that was proposed in 1938, and to bring to your attention Trout's and Evans' conclusions. It is generally true that the body of a normal person is capable

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of handling relatively large amounts of isotonic saline solutions without showing signs that would indicate that a significant derangement in the regulation of body functions had occurred. However, there are many individuals who are incapable of tolerating relatively small excesses of salt solution, *during the immediate postoperative period*. The type of illness that may follow the administration of saline or Ringer's solution varies. There are three predominant and fairly distinctive symptom and sign complexes. The cases that are presented illustrate these arbitrary complexes.



Case 1 represents the most insidious and, in our experience, the most common form of "salt intolerance". The symptoms and signs are primarily referable to the central nervous and digestive systems. They are weakness, disorientation, anorexia, nausea, vomiting, distention and an increasing depth of respiration. The rate of urine excretion decreases slowly, the N P N of the blood increases, the carbon dioxide combining power falls, and the plasma chloride level tends to remain constant although a large amount of salt may be administered in an attempt to raise it should it be below normal. Recovery is slow. Paradoxically, as the person improves the plasma chloride level, if it is low, rises without the administration of the chloride ion.

Case 1—W C, male, age 73 was operated upon under a spinal anesthetic that

POSTOPERATIVE SALT INTOLERANCE

CHART II

M L ♀ 61 yr Adenocarcinoma rectum Comb Abd -perineal resect Spinal anesth										
	Pre-Op	Oper	1	2	3	4	5	6	7	8
Oral	0	0	0	0	0	200	0	0	200	0
Saline		3000	3000					700	300	300
Glucose				3000	2000	2000	3000	2000	2000	2000
Lactate					250	250			500	
Blood		500								
Urine O-P		990	1380	1750	1125	1700	1750	1850	1150	1150
Emesis			150			750	700	100		
Wangensteen					1050		800	50		
NPN mg/100	25	22		19		31				
CO ₂ vol %	59	56		55		77	77			68
Chloride mg%	634	634		622		535				568
Progress	Consid a good risk	Duration 2½ hours No shock	Nausea, emesis Drowsy Abd Dist Colos not funct			Emesis Abd Dist		General Improvement obvious Alert Abdomen soft		

had to be supplemented with ether. A resection of a neoplasm of the ascending colon and an ileotransverse colostomy were performed. On the first postoperative day, oliguria was present. During the first five postoperative days a positive fluid balance of five liters was amassed. With it the clinical signs of acidosis developed and a chemical analysis of blood on the fourth postoperative day substantiated the clinical opinion. The plasma chloride level was found to be low, the apparent deficiency of chloride was thought to be due to an excessive loss through gastric drainage and transudation into the small gut. As a consequence, upon the basis of the "clinical rule,"* 4000 cc of saline were given intravenously in addition to 1900 cc of 5 per cent glucose. His condition deteriorated rapidly, the distention increased in spite of massive gastric drainage, edema appeared, he became completely disoriented, and his urinary excretion decreased. However, the plasma chloride level remained stationary instead of rising to about 560 mg per cent as had been anticipated. The next morning 2000 cc of saline and 1000 cc of glucose solutions were given and by evening he had excreted only 225 cc of urine (12-hour period). His condition was precarious, respiration was noisy and difficult, the edema had increased and cyanosis had appeared. It was realized then that the initial low chloride content of his plasma represented an attempt to compensate for an acidosis which likely had both an organic (urinary suppression) and a respiratory component (distention and emphysema).

Three liters of 10 per cent glucose, mercupain and epinephrin in oil were given to him. In the next 12 hours 1350 cc of urine were excreted. The CO₂ combining power rose, the N P N began to fall and respirations became dry and easier. On the sixth postoperative day the intern, from habit, ordered saline, and 900 cc had

CHART III

O P ♂ 78 yr Adenocarcinoma rectum Colostomy Spinal Anesthesia							
	Pre-Op.	Oper.	1	2	3	4	5
Oral	0	0	0	0	0	1750	1910
Saline		2000	3000				
Glucose				3000	2000		
Lactate				250			
Urine O-P		1550	850	1505	2550	2000	1125
NPN mg%	43	41		41			
CO ₂ vol%	33	35		42			
Chloride mg%	634	648		607			
Progress		Disoriented		Drowsy Abd dist Edema eyes, ankles		Improved mentally Dist less Edema less	
						Clinically improved. Cheerful, well orient- ed No edema	

* For each 100 mg per cent the plasma chloride is below 560 mg per cent, give 0.5 Gm of salt per kilo of body weight

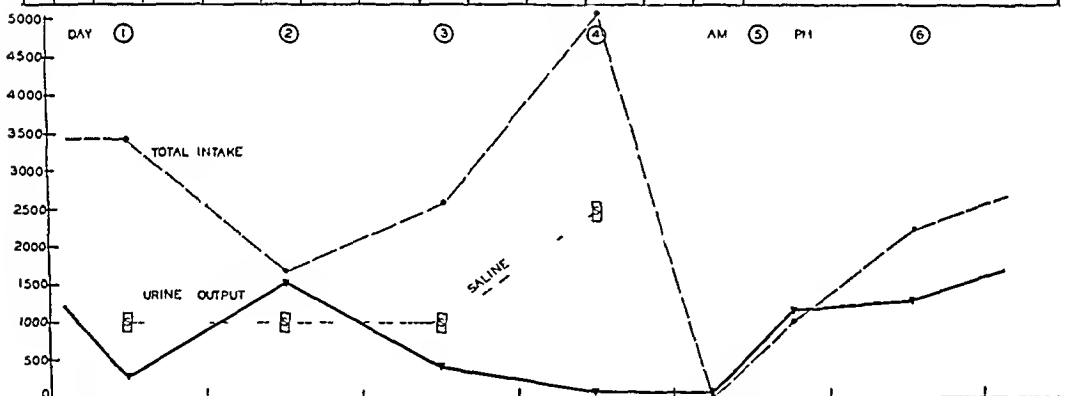
been given before the error was discovered. The patient's recovery was gradual and was associated with a negative fluid balance for seven days (Chart I).

Cases 2 and 3—Cases 2 and 3 (consult Illustrations II and III) show that the early symptoms and signs that accompany a relatively small, acute chloride excess are not accompanied by, or due to, any gross changes in acid base equilibrium, plasma chloride, or N P N. This observation substantiates the conclusions of Sippel and of Evans, in that it makes it appear that the toxic symptoms may be attributable to the excess of the chloride ion in saline solution*. These three cases and many others have convinced us that the use of the "clinical rule" for chloride replacement is dangerous, especially when employed without a sound knowledge of biochemistry and physiology, and that it should not be employed.

CHART IV

AB 58 RUL LOBECTOMY

PQ	CO ₂	PLASMA	PLASMA	ORAL	SALINE	GLUCOSE	BLOOD	LACTATE	TOTAL	URINE	EMESIS	DRAIN	REMARKS
DAY	NPN	VOL %	NACL	PROTEIN					INPUT	OUTPUT		WANG.	
1					+	1000	1900	500	3400*	300			5-HOUR ANESTHESIA—REACTED WELL
2					690	1000			1690	1535			FAIR DAY
3					600	1000	1000		2600	400		500	LARGE LIQUID STOOL VOMITING—ABDOMINAL DISTENTION
4					100	2500	2500		5100	135	1250	500	CONDITION WORSE IRRATIONAL—ABO DISTENTION—NO FLATUS
AM 5		77			0	0	0		0	110		1760	CONDITION VERY POOR—IRRATIONAL HICCOUGHS—LUNGS WET—MUCOID SPUTUM
PM 5					0	0	0	1000	1000	1150	0	1000	STRIKING IMPROVEMENT AFTER LACTATE
6	55	87	413	4.46	500	250	1000	500	2250	1250	0	0	HUNGRY—EATING AND DRINKING RATIONAL—LUNGS DRY—RECOVERY



Case 4—A B, male, age 58, underwent a right upper lobe lobectomy. Ether vapor was used as the anesthetic agent. The general features of his illness, a fulminating oliguria that was associated with a rapid physical deterioration, are similar to those of the case reported by Sippel in 1910. The usual immediate temporary postoperative oliguria is apparent (Chart IV). During the forenoon of the third postoperative day he was found to be distended, he began vomiting, and he passed a large liquid stool. The urinary rate of flow began to fall after the diuresis of the second postoperative day and by the fourth day only 135 cc of urine were excreted in the preceding 24 hours. He became irrational, and in spite of the administration of 5,000 cc of intravenous fluids (2,500 saline) during that day, he excreted only 110 cc of urine in 12 hours. His condition had become precarious (Chart IV). One thousand cubic centimeters of M/61 sodium lactate were given†. During the next 12 hours 1,150

* The chloride ion concentration in isotonic saline is greater in relation to the sodium ion than it is in plasma.

† Unpublished work indicates that the oliguria accompanying "salt intolerance" is best relieved by the administration of sodium that is not in combination with chlorine or the anions of other strong acids.

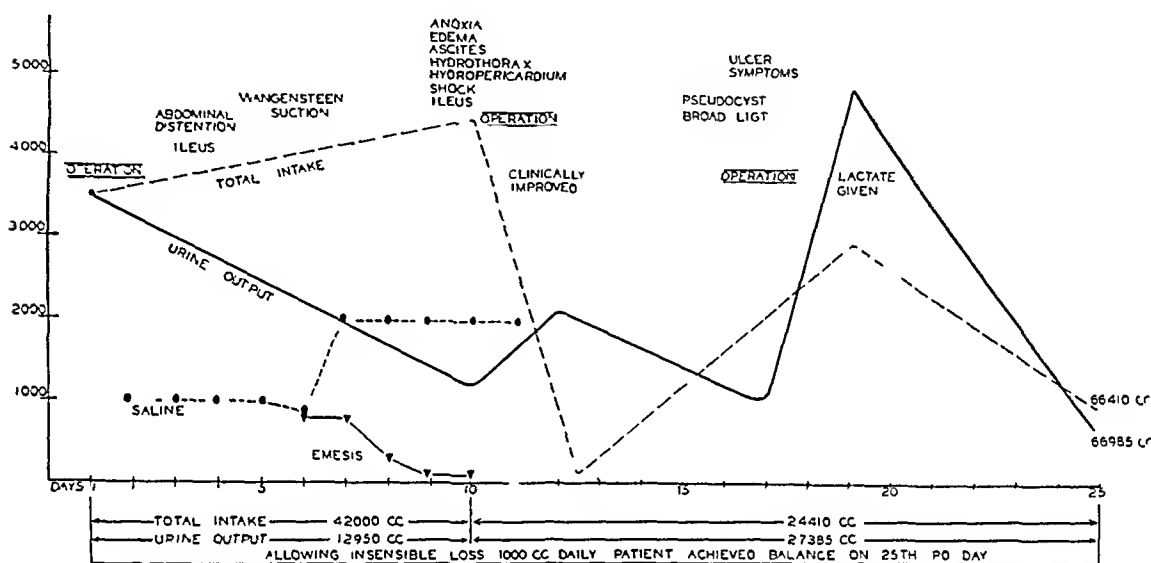
POSTOPERATIVE SALT INTOLERANCE

cc of urine were excreted and thereafter his improvement was rapid. This man had had frequent examinations of urine made preoperatively and no red blood cells, casts, or albumin had been found.

The fifth case (Chart V) demonstrates an extreme accumulation of fluid in serous cavities as a result of a relatively prolonged, though a slightly excessive, administration of sodium chloride.

Case 5—G B, female, age 40, underwent a subtotal hysterectomy under ether anesthesia. She was given daily 1000 cc of isotonic salt solution in addition to 2000 to 2500 cc of 5 per cent glucose. On the fourth postoperative day she became

CHART V



DATE	SOURCE FLUID	NPN	TOTAL N	ALBUMIN NIT	GLOBULIN NIT	A/G RATIO	TOTAL PROTEIN	CHLORIDE	SODIUM	POTASSIUM	REMARKS
8-28	ABDOMEN	35.2	481.9	288.3	158.4	1.71	2.79 GM%	98.5 MEQ/L	133.8	4.86	4.5 LITERS RECOVERED
9-1	ABDOMEN		232.7	+++	+		1.45				PARACENTESIS
9-2	TUMOR	151.9	2800	+++	0		0.80	88.75	133.8	6.62	COLPOTOMY

DATE	GLOMERULAR FILTRATION RATE	C_1	EFFECTIVE RENAL BLOOD FLOW	C_D	FILTRATION FRACTION	C_x/C_0	REMARKS
8-28	101 CC/MIN		398 CC/MIN		0.364		10 DAYS PO
9-4	71.7		305		0.397		
9-18	44.7		300		0.223		RT HYDRONEPHROSIS

distended, on the fifth day she began to vomit, on the sixth day gastric suction was begun and the parenteral fluids were stepped up to 2000 cc of saline and 2000 cc of 5 per cent glucose *per diem*.

Her distention increased rapidly in spite of profuse gastric drainage, by the evening of the tenth postoperative day she was practically *in extremis*. The distention was so great that the respiratory excursions were practically imperceptible. She was deeply cyanotic in spite of the fact that her hemoglobin was less than 60 per cent of normal. Her pulse was small, late, and thready, and her apex beat was very weak. A generalized one plus edema was present. During the ninth and tenth postoperative days repeated attempts had been made to pass a Miller-Abbott tube but they were not successful. Because death from respiratory embarrassment was almost certain within a matter of hours unless the distention could be reduced, it was decided that a gastrotomy should be performed and an attempt made to pass the tube directly through the pylorus. Upon entering the abdominal cavity a massive ascites was encountered, four liters of fluid were collected and another liter was estimated to have been lost.

The sodium and chloride ion concentration in this fluid was the same as it was in her

plasma The protein content was 2.79 Gm per cent with an A/G ratio of 1.71 Her stomach wall was approximately 2 cm thick, her liver was enlarged and so soft that it felt like a hollow viscus The small intestine was distended with fluid and only a small amount of gas was seen in it There was no gross edema of the small intestine Her omentum was a thick, amorphous, opalescent mass After the greater part of the ascitic fluid was removed, the wound was closed By the time she was placed in bed respirations were normal, her pulse rate had fallen, blood pressure had risen from 60/20 to 100/70, and consciousness had returned No more "physiologic" saline was given to her and she recovered

Cases 1, 2, 3, and 4 differ from Case 5 in that the bloods of the former contained normal amounts of hemoglobin and plasma proteins and no physical renal complications were introduced when they were operated upon Case 5 suffered from a microcytic hypochromic anemia and hypoproteinemia (Hb 46 per cent and p.p. 4.26 Gm per cent) at the time she had been operated upon* and on the sixteenth postoperative day her right ureter was found to have been obstructed at the level of the pelvic floor This case demonstrates clearly the "washing out" effect of salt solution upon the serum proteins and the increased tendency for salt retention in hypoproteinemic states, facts which have been brought previously to our attention by Blalock

Cases 1, 4, and 5 and nine others came to our attention during a three-month period during 1942† Since that time no saline or Ringer's solutions have been given during the operative and immediate postoperative (48-hour) periods unless losses of extracellular fluid occurred (diarrhea, sweating, fistulous drainage, etc) Extracellular fluid losses are now being replaced according to the volume for volume rule by 0.5 per cent NaCl solution to which 50 Gm of dextrose per liter has been added The water needs of the patients are met entirely with plain glucose solution The practice of giving 5 Gm of salt daily "for maintenance" has been discontinued because the salt conserving capacity of the kidneys is practically perfect

The clinical rule (see footnote page 535) for correcting extracellular fluid deficiencies has been found to be highly inaccurate and dangerous Its formulation and use in the University of Michigan Hospital was based upon the assumptions that the chloride level of the plasma varied directly with the extracellular fluid volume from a normal of 560 mg per cent and that the plasma chlorides maintained a fixed relationship with the sodium ion Both suppositions had been proven to be false, especially during illness, at the time the rule was proposed It has been known for many years that the chloride level of the plasma could vary without a significant change in the hydration of the body An increase of blood anions, other than chloride (bicarbonate, phosphate, citrates, acetone bodies, and lactate) is associated with a compensatory fall in chloride and need not be associated with any significant change of E.C.F.

In addition, a non-compensatory decrease of the plasma chlorides signifies that a dilution of plasma (E.C.F.) electrolytes has taken place The

* Repeated unsuccessful attempts had been made to give her blood preoperatively

† Cases 2 and 3 were induced during an investigation of the problem

rate and extent of the dilution has no fixed relationship with the state of hydration, especially in different individuals. Therefore, the plasma chloride level alone cannot serve as a sufficiently accurate base for the construction of a universal hydration formula. The failure of the formula and its dangers are well illustrated in Cases 1 and 4. Earlier observations regarding the efficacy of the formula were made by Poweis, *et al*.

At present, the restoration of extracellular fluid deficiencies is not being made primarily upon the basis of variations from normal of ions or molecules in blood (Cl, CO₂ combining power, plasma proteins, Hb, *etc*) but upon the basis of the clinical status and physiologic response of the individual to test doses of parenteral fluids.

Examples may serve to clarify this method.

Example 1—A patient, age 60, enters the hospital with pyloric obstruction. He has been vomiting for three weeks. He has lost 20 pounds. He is not thirsty, the specific gravity of his urine is 1.014, his temperature is normal, his pulse is 80 and full, he answers questions readily and at length, he complains of slight lassitude. His plasma chlorides were 460 mg per cent and the CO₂ combining power was 50 vols per cent.

The lack of thirst and the low specific gravity of his urine indicate that he has been retaining enough water to prevent dehydration. His normal temperature, normal mental responses, and normal pulse indicate that although his extracellular fluid volume may be below his ideal normal the reduction has been fully compensated. The low plasma chloride is not regarded as an indication for the immediate administration of over three liters of saline as would be given should the "clinical rule" be employed. Instead the low chloride level is considered to be compensatory to the "starvation acidosis" (weight loss of 20 pounds in three weeks), and only one liter of saline is given to him as a test dose. If his physiologic status does not change after receiving the saline he is considered to be compensated and on succeeding days the gastric aspirations are replaced by equal volumes of 0.5 NaCl solution, in addition to glucose solution in sufficient amount to prevent thirst and maintain the specific gravity of the urine below 1.020.

Example 2—A man, aged 60, suffering from pyloric obstruction enters the hospital after vomiting for three weeks. His weight has decreased 30 pounds within that period. He is thirsty, his temperature is 97° F, his pulse is 80 and soft, he answers questions in monosyllables, he goes to sleep between questions, his respirations are shallow and slow. The specific gravity of his urine is 1.028, the plasma chlorides are 400 mg per cent, his CO₂ combining power is 90 vols per cent.

The thirst and high urine specific gravity indicate a need for free water. The subnormal temperature, apathy, and soft pulse show that a dangerous reduction in extracellular fluid volume has occurred. The alkalosis is disregarded.

MANAGEMENT

The intravenous drip is set as follows

1st bottle—10 per cent glucose, 1000 cc

2nd “ —Ringer’s solution, 1000 cc

3rd “ —10 per cent glucose, 1000 cc

If thirst remains or if the specific gravity of the urine is above 1.020, the fourth bottle is glucose. If not, it is Ringer’s solution, and the second bottle of Ringer’s is given very slowly (200 cc per hour). Should the patient’s pulse fill out, his mind become clearer and his temperature rise appreciably before the second liter of Ringer’s has been given, the injection is stopped.

Upon each succeeding day glucose is given first in amounts sufficient to allay thirst completely and to keep the specific gravity of urine at least in the 1.010–1.020 range. This is followed by one liter of Ringer’s solution daily (in excess of the volume-for-volume replacement of drainage by 0.5 per cent, Ringer’s) until the CO_2 combining power and plasma chloride values have become constant. If the plasma Cl and CO_2 combining power reach plateaux before their arbitrary so-called normal values are reached, no attempt is made to change them further. Considerable departure from normal in Cl and CO_2 combining power can be expected in starvation, emphysema, etc.

The type of saline solution administered also depends upon the clinical status of the patient. In the preceding examples simple repair solutions (saline or Ringer’s solution) will satisfy requirements. However, in a case such as follows, a buffered solution is considered to be indicated.

Example—Patient age 70, weight 60 Kg, with pyloric obstruction and vomiting for three weeks, entered the hospital in semicoma. Urine, catheterized—20 cc, sp gr 1.035, contained albumin, casts, and red blood cells. Respiration was deep and labored, pulse weak and irregular, CO_2 combining power 30 vols per cent, plasma chlorides, 200.

In this case urinary suppression has resulted in a retention of acid radicles of sufficient degree to counteract the tendency of chloride reduction to produce an alkalosis and instead a severe “uremic” acidosis is superimposed upon a reduction of total base from vomiting. This man obviously is in great need for a rapid replacement of extracellular fluid, but in the face of the anuria, no solution should be given which has a chloride content in relation to sodium that is greater than is present in his plasma, or the acidosis may be increased beyond tolerable limits. For that reason, normal saline and Ringer’s solution (chloride, 150 m eq vs 100 m eq in plasma) are considered to be less adequate from a physiologic standpoint than Hartmann’s solution. The plan of administration is as previously outlined.

SUMMARY AND CONCLUSIONS

- 1 Three clinical types of “salt intolerance” are described.
- 2 Because of the relatively high incidence of “salt intolerance” following a general anesthesia, it is felt that no *isotonic* saline solution or Ringer’s solution should be given during the day of operation and during the subsequent

first two postoperative days The fluid requirement of the patient is met with glucose solution If a significant loss of extracellular fluid occurs during the above period, it is replaced with 0.5 per cent sodium chloride solution to which 50 Gm per liter of dextrose has been added Isotonic saline solution (0.9 per cent) or Ringer's solution is used to replace extracellular fluid loss after the postoperative urinary suppression has disappeared, usually after the second postoperative day

3 Great care must be used in administering isotonic saline and Ringer's solution to patients who are hypoproteinemic, anemic, acidotic, or oliguric

4 It is recommended that the correction of uncompensated extracellular fluid deficiency states be made upon the basis of the physiologic response to test doses of the appropriate salt solution rather than upon the basis of the plasma chloride, the CO_2 combining power, the N P N, the plasma protein, or the hemoglobin levels Three examples are given to illustrate the method

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DISCUSSION—DR ROBERT L RHODES, Augusta, Ga Doctor Collier referred to a paper published in 1913 by Doctor Trout, with whom I was associated at the time I had not thought of that for a long time I am reminded in these days of shortage of man power and woman power in hospitals of some thoughts brought out in that paper In 1910 we began a comparative study of rectal administration of salt solution and water, on alternate cases operated upon, there were 2000 consecutive cases, 1000 of each Out of the 1000 that had salt solution, approximately 125 or 150, 12 to 15 per cent developed edema, and when the salt solution was shifted to water the edema subsided

It is a very simple matter to give water by drip, not the Murphy drip, but the Lawson drip, described by him in May, 1909 The original dropper was a simple medicine dropper inserted into a test tube When first brought out the dropper was too slender, so that if not held perfectly erect the drop would span the gap between the two tubes and syphonage would result instead of drops The larger bulb effect was designed by me, and first made by Woche of Cincinnati upon order for us This bulb avoided syphonage even when lying almost flat Later someone stuck a hole in the bulb with the thought of allowing gas to escape, but what it really does is allow suction of air to come into the bulb and be carried into the rectum between the drops of the solution and produce irritation of the rectum When this hole is sealed-off with adhesive tape and the dropper is regulated to 40 drops per minute, you have a foolproof mechanism At this rate the fluid is absorbed about as rapidly as it is introduced and any collection of gas in the rectum is easily expelled beside the small indwelling catheter

As he published, the amount of water a patient would take is approximately one pint more than salt solution, without producing edema John B Murphy was the first to suggest rectal administration of fluid, but with a large tube which produced irritation Our studies show that a small catheter slipped into the bowel for three or four inches and strapped to the buttocks would not irritate the sphincter muscle or rectum, could be left in position for days and, at 40 drops per minute, three quarts of water, saline or glucose could be easily given in 24 hours Many medicines may be added to the solution and given in this way

DR ALFRED BLALOCK, Baltimore, Md I admire a person who can find imperfections in his own work Doctor Collier, and his associates, have been correct in most of their teachings on the treatment of dehydration and I am delighted that it is they rather than others who find that the quantity of salt solution which they have recommended under some circumstances has been excessive

I am particularly interested in Doctor Collier's remarks on the effects of an excessive quantity of salt solution on the kidneys Some of the peculiarities of the kidneys in impending or fully developed shock have been pointed out recently by Van Slyke, and his associates It is well known that the blood flow through the extremities diminishes greatly in early shock It has not been appreciated that the kidney circulation behaves in a similar manner With only a slight diminution in the arterial blood pressure, the renal blood flow usually declines quite markedly This reduction in flow is particularly bad since the kidneys (unlike the extremities) do not remove increasingly large amounts of oxygen from the reduced quantity of arterial blood passing through them In other words, the oxygen consumption of the kidneys in impending peripheral circulatory failure is considerably reduced These observations may explain in part the interesting findings of Doctor Collier

Doctor Ochsner spoke this morning of the interesting recent work of Doctor Rosenthal on the experimental use of salt solution in treatment of burns Perhaps it is well to point out that rather tremendous amounts of fluid were given and that this was administered before shock had developed

In the treatment of shock we should attempt to make up for the deficit in blood volume by administering fluid of essentially the same composition as that which has been lost Despite the great virtues of blood plasma, I think that we have too great confidence in its usefulness under certain circumstances Many instances of shock are due to the loss of whole blood and replacement therapy should include the administration of whole blood The necessity for this has been emphasized by Doctor Churchill Doctor Beecher, and others One should bear in mind that red blood corpuscles are needed for the transport of oxygen Even though the blood volume is brought back to an essentially normal level by the administration of plasma following hemorrhage, the anemia causes a great increase in the amount of work which has to be performed by the heart

TREATMENT OF METASTATIC CARCINOMA OF THE NECK*

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CARCINOMA OF THE MOUTH AND LIPS tends to remain confined in the head and neck, thus presenting a considerable chance of cure even after metastases have occurred. As early as 1906, Crile²⁵ published the findings of a review of 4,500 autopsies in which distant metastases were found in less than 1 per cent and though other slightly higher figures have been published since, all have been under 10 per cent.

The first metastases usually appear in the lymph nodes which drain the immediate area, and in this stage the disease is still relatively curable. Subsequently, there may be widespread permeation throughout the neck on both sides anteriorly and posteriorly, probably because of the extensive lymphatic communications.

As elsewhere in the body, the metastases vary with the grade of malignancy of the primary lesion. A huge, fungating lesion of long duration may be accompanied by no cervical metastases while another patient may have large neck masses from a minute ulcer in the mouth or pharynx which may be difficult of detection.

Cervical metastases occur with such frequency, however, that any good plan for treating these patients must be directed toward the cervical nodes as well as the primary lesion (Fig 1). In general, the choices of treatment are radiation or surgery, or some combination of the two.

RADIATION TREATMENT

External roentgen radiation is still advocated by some workers for operable metastatic squamous carcinoma in the cervical lymph nodes. In the literature for the last fifteen years, however, no five-year cures from this treatment were found where the disease had been definitely proven by nodal biopsy. Negative evidence has been supplied by Simmons¹⁰⁷ who reported 108 cases, and Forsell⁴⁷ (from the Radiumhemmet) who reported 72 cases (treated by external radium or roentgen radiation) without even one cure. Many radiologists have taken a definite stand against this form of treatment †

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

† Berven⁴ (from the Radiumhemmet in Stockholm) stated "Roentgen treatment, as technically carried out at present only seems capable of producing shrinkage of the glands for some longer or shorter period of time with subsequent palliation. The metastases later begin to grow in spite of roentgen treatment then undertaken."

All of the reported five-year radiation cures, in which positive nodal biopsies were obtained, have been from interstitial implantation of radon seeds directly into the nodes and surrounding tissue, often after surgical exposure. Auxiliary roentgen radiation has also been employed in some instances. Clarkson²¹ reported one case in which the node involvement was metastatic from the face and radon was implanted after its removal. Both of the other reports have been from Memorial Hospital, and Martin's⁶⁸ series apparently included Duffy's.³¹ Duffy's patients all had operable neck masses and he found after examining the records at Memorial Hospital over many years, that there was never more than 2 per cent variation in the 20 per cent cure for surgery and the 4 per cent cure for radiation of operable metastases (Table I).

TABLE I

FIVE YEAR CURES IN PATIENTS WITH MICROSCOPICALLY POSITIVE CERVICAL LYMPH NODES
REPORTED IN THE LITERATURE 1927-1942

Radiation Only				Neck Dissection				
Author	Cases Treated	Cases Well*	% Well	Author	Cases Treated	Cases Well	% Well	Primary Lesion
Duffy ³¹	68	3	4.4%	Duffy ³¹	45	9	20%	Mouth
Clarkson ²¹	?	1	?	Morrow ⁹¹	26	3	11%	Tongue
Martin H ⁶⁸	?	46	?	Fischel ⁴³	48	17	35%	Mouth and lip
				New ⁹²	57	8	14%	Tongue
				New ⁹²	45	11	24%	Jaw
				New ⁹²	50	18	39%	Lip
				Martin H ⁶⁸	65	17	26%	Mouth and lip
				Blair & Brown ⁹	74	20	27%	Mouth

* All radiated cures received interstitial radon implants

Cases of subsidence of swollen cervical nodes have been frequently reported following external radiation, but surgeons have often noted that clinically suspicious nodes may prove to be inflammatory on microscopic examination (Table II).

TABLE II

Patients Well Following Radiation of Enlarged Cervical Lymph Nodes (Presumably Without Positive Nodal Biopsies)					Incidence of Negative Microscopic Findings Following Neck Dissections for Enlarged Nodes	
Author	Cases Treated	Cases Well	% Well	Time	Author	Pts with Neg Node
Coutard ²⁴	162	27	16%	5 yrs	Broders ⁴⁹	38.5%
Quick ⁵⁶	161	12	7%	?	Simmons ⁴⁹	55%
Engelstad ³⁸ (mouth)	81	5	6%	?	Duffy ²⁹	25%
Engelstad ³⁸ (lip)	68	18	26%	3 yrs	Fischel ⁴³	28%
Martin C L ⁶⁸ (face lip mouth)	39	8	20%	4 yrs	Blair Brown & Womack ⁵	35%
Shreiner & Mattick ¹⁰⁴ (lip)	38	8	21%	5 yrs		
Wookey ¹⁰³ (mouth)	53	0	0%			
Forsell ⁴⁷ (mouth)	72	0	0%			
Simmons ¹⁰⁷ (mouth)	108	0	0%			

Sherwood Moore,¹² of St. Louis, has written "There may have been cases of cervical gland metastases treated by radiation that have recovered, but offhand I cannot recall an example of it in my experience." Quick's⁹⁸ opinion is that "Complete control of epidermoid carcinoma metastases in the neck is but rarely effected by external radiation alone. Growth restraint only is the expectancy."

It is rare to find any report of five-year cures following irradiation of swollen nodes in which the percentage is higher than the normal expectancy of inflammatory nodes would be

SURGICAL TREATMENT

The surgical treatment of malignant disease in general leaves much to be desired and it is to be hoped that some day we will have a more efficient method. This hope stimulates continuous investigation and interest, but it



FIG 1—Bilateral upper neck dissection in patient who had carcinoma of the lip. Metastases were demonstrated microscopically in the nodes and the patient remains well 11 years after operation. This operation has an extremely low mortality, is not especially disfiguring, and produces a worthwhile percentage of five year cures when indicated.

should not lead to the acceptance of inferior or unproven methods. Any treatment supplanting surgery should surpass its known results when meeting the same criteria which have long been applied to the surgical treatment of cancer, namely, the percentage of patients with positive microscopic diagnoses who are living and well five years after the beginning of treatment (Fig 1).

Block removal of lymph nodes draining the area seems to be an established principle in cancer surgery and their removal from the neck is more anatomically feasible than from other areas. It does not seem logical to have a patient with a carcinoma of the breast in whom an axillary dissection has been done, in one ward, and a patient with a carcinoma of the mouth in another ward, in whom the neck nodes are either not treated, or are treated by some feeble method.

The results of neck dissection have been far from perfect, but a very worthwhile percentage of cures has been reported from many clinics (Table 1).¹ The group listed here does not contain all that have been published, but only those in which five-year results were listed and in which the microscopical findings were easily ascertainable. Variations in the percentage cured are probably reflections of differences in the locations and malignancy of the primary lesions, as well as the criteria established for operability and inoperability (Fig 2).

* Our own series is not reported in this paper as it is rather small and has been published, in part, elsewhere.²

CRITERIA FOR NECK DISSECTIONS

It is thought that the rule should be to undertake dissections in patients with primary carcinoma of the lip or mouth. Deviations of care of individual patients are made *away* from this rule, rather than making it a last resort. Exceptions have to be carefully considered. Fixation of the metastases to the skull or vertebral column is a contraindication, but fixation to the lower jaw is not necessarily so, though the percentage of cures will be smaller. Fixation

to the common carotid artery or vagus nerve is usually a contraindication, though occasionally worth while results may be obtained (Fig 3). Widespread involvement of the anterior and posterior triangles on both sides of the neck is a contraindication. Bilateral complete dissections may be undertaken in two stages if involvement of the second side occurs later and the first side has remained well (Fig 4). Several patients have had a complete neck dissection on one side combined with an upper neck dissection on the other side in one stage, when there has been involvement of the upper neck on both sides and the lower neck on one side. The highly malignant, anaplastic, "lympho-epitheliomas" of the hypo- and nasopharynx and tonsillar region have given poor results surgically and are



FIG 2—Patient well 10 years after complete unilateral dissection for metastatic malignant melanoma (primary site was on the temple). A few weeks after the dissection a coal black area of recurrence was present in the skin scar and this was widely excised with the cautery, with subsequent cure.

somewhat radiosensitive, so that they are usually treated by the latter method, this is an excellent contribution for which Coutard²⁴ deserves much credit (Surgical excision and neck dissection, as described by Trotter,¹¹⁹ may be considered in well differentiated lesions of the hypopharynx).

Probable incurability of an advanced local lesion has been an indication for omitting neck dissection, or at least delaying it until the results of the local treatment can be determined. On the other hand, when it is thought that the local lesion can be eradicated, neck dissection has been done simultaneously or soon after the local treatment without waiting to see the results of the latter. This is at variance with some who believe that the neck dissection should never be done until the local lesion has been cured, but operable neck masses may become fixed and inoperable while awaiting complete retrogression of a local lesion from interstitial radiation, or primary healing following operation.

The general health of the patient is rarely a contraindication to the operation, as nearly all of these patients are over 50 or 60 years of age, and have

METASTATIC CARCINOMA OF NECK

varying degrees of arteriosclerosis, heart disease, prostatic obstruction, lowered renal function, etc. The mortality is generally below 5 per cent as long as the neck dissection is not combined with an extensive mouth operation*. The operative mortalities with complete dissections have nearly all followed some operation of considerable magnitude for an advanced lesion, such as combining the dissection with a cautery destruction of the jaw or floor of the mouth, or with an upper neck dissection on the opposite side. Successful dissections have been done in controlled diabetics, in patients nearly 90 years of age, and in the presence of advanced heart disease and orthopnea, but the mortality will necessarily be higher in such instances.

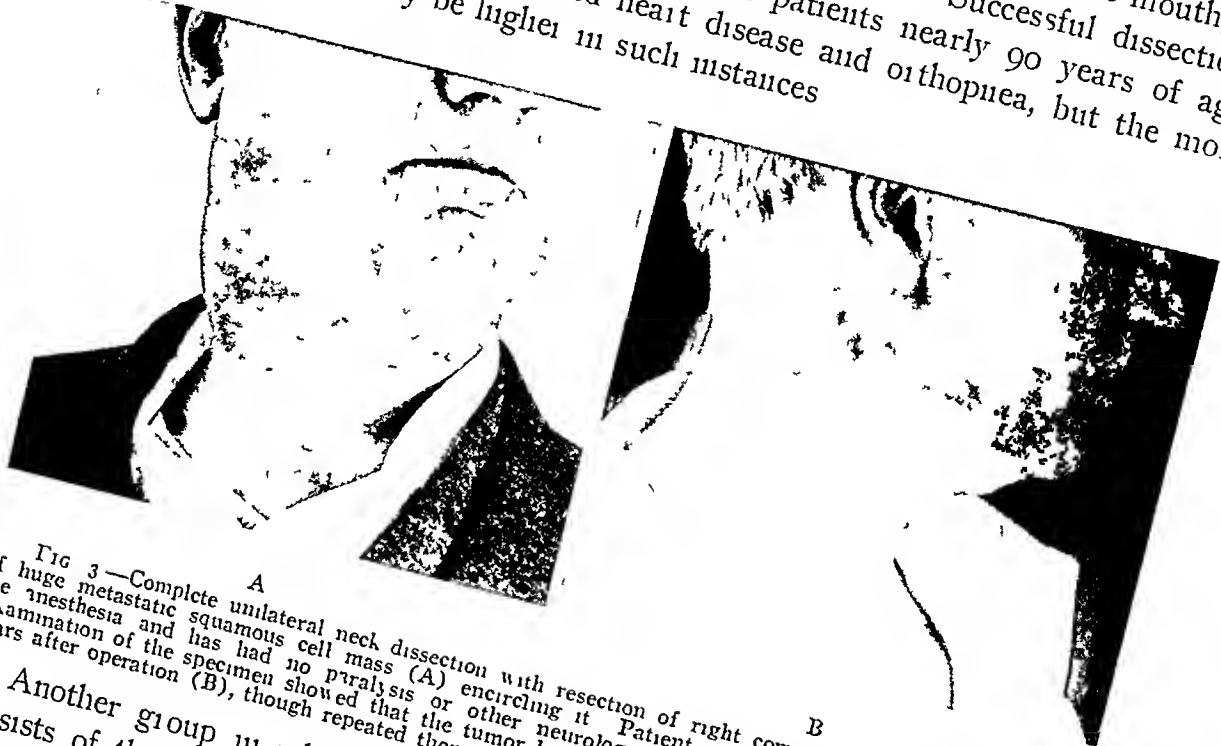


FIG 3—Complete unilateral neck dissection with resection of right common carotid artery because of huge metastatic squamous cell mass (A) encircling it. Patient awakened in the usual time after the anesthesia and has had no paralysis or other neurological disturbances and works every day. Examination of the specimen showed that the tumor had been compressing the artery. Well now four years after operation (B), though repeated thorough examinations have never revealed the primary site.

Another group in whom dissection is sometimes indefinitely postponed consists of those elderly patients with early, low-grade lip lesions and no enlarged cervical nodes, particularly if satisfactory arrangements can be made for follow-up examination of the neck each month.

Neck dissections have occasionally been done for diseases other than metastatic squamous carcinoma when thorough investigation has failed to reveal any spread beyond the neck. These have included malignant melanoma, lymphosarcoma, and reticulum cell sarcoma, but the prognosis is generally poor in all of these (Fig 2), and radiation may be better for the latter two. Neck dissections are not done for tuberculosis of the cervical lymph nodes, as radiation therapy seems definitely better.

TYPE OF NECK DISSECTION INDICATED

The purpose of the operation is the removal of any lymph nodes which are, or may be, involved by the disease. Taylor and Nathanson's¹¹³ work on the lymphatic drainage from the mouth and lips serves as an excellent guide.

* Hayes Martin⁶⁸ has reported 27 per cent, and Fischel⁴³ 36 per cent mortality from complete neck dissections, and Fig¹¹¹ 18 per cent mortality from upper neck dissections.

for determining where the metastases will probably occur. In ulcerated mouth lesions, a further guide is sometimes afforded by the presence of enlarged inflammatory nodes.

In general a complete neck dissection is done on one side for lesions on the lateral border of the tongue, the buccal mucosa, the lateral portion of the floor of the mouth, or the upper jaw or palate on one side. Alveolar lesions on the lateral aspect of the lower jaw involve the bone nearly always, so that an upper neck dissection combined with cautery destruction of the jaw is usually done. These lesions metastasize rather slowly, but if firm enlarged



FIG 4.—Bilateral complete dissection for carcinoma of the tongue. The first side was done at the time the tongue was treated and crossed metastases appeared one year later in the carotid sheath, necessitating a complete dissection on the second side. Well seven years after the first side and six years after the second side.

nodes are already present in the neck, a complete neck dissection on that side with a cautery destruction of the jaw may be done, though with an anticipated higher operative mortality.

A bilateral upper neck dissection is usually done for those lesions of the floor of the mouth, or alveolus which approach the midline, unless there are already enlarged firm nodes on one side, in which case a complete dissection on that side and an upper neck dissection on the opposite side may be done, again with a higher operative mortality. The same rule is applied to carcinomas of the lower lip, that of regional node removals, usually doing a bilateral upper neck dissection as nearly all of these lesions approach the midline, but doing a complete operation on one side when the lesion is near the angle of the mouth and when enlarged, hard nodes are already present on that side.

The complete neck dissection is done much as described by Crile,²⁵ in 1906, with a few modifications. Its purpose is to remove as much of the lymphatic-bearing tissue as possible. The area of excision extends superiorly along the body of the lower jaw through the tail of the parotid to the mastoid, posteriorly along the border of the trapezius muscle, inferiorly across the top of the clavicle, and anteriorly up along the ribbon muscles to the hyoid and

then across the midline to the opposite side of the chin. The block excised contains the subcutaneous fat and fascia, the sternomastoid muscle, internal jugular vein, the submaxillary gland and part of the parotid, and extends internally to the ribbon, scaleni, levator scapulae, trapezius and mylohyoid muscles. The carotid arteries are left intact as well as the vagus and 12th nerves (though the ansa is removed) and often the portion of the 11th nerve supplying the trapezius is not removed if involvement in that area is not expected (Fig 5). By separating the stylohyoid and digastric muscles from the hyoid, and dividing the digastric tendon, it is possible to remove the entire block from the clavicle to the head in one piece, and it is desirable to keep any involved nodes deep within the excised tissue and not expose them.

Upper neck dissections are usually done bilaterally and do not include removal of the sternomastoid muscle or jugular vein. An incision is made from one mastoid to the other, crossing the midline of the neck just above

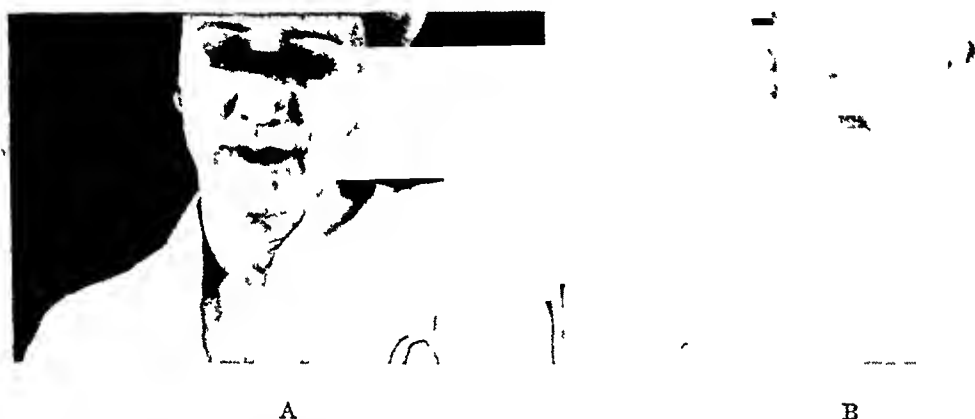


FIG 5—Showing the effect on shoulder action of saving the 11th nerve. (A) Complete dissection in a young woman with preservation of the 11th nerve. (B) "Shoulder drop" in another patient in whom the 11th nerve was not preserved because of palpable nodes in the region. Also shows effect of preserving the lower branch of the seventh nerve in the first patient.

the hyoid and the superior flap is reflected upward on the face. The inferior flap is retracted downward in the region of the carotid sheath and the deep superior cervical nodes are removed by dissecting the sheath (and its included fat and lymphatics) upward, beginning about one inch below the carotid bifurcation. After the upper carotid sheath has been cleaned out, the dissection is carried upward on the surface of the mylohyoid and sternomastoid muscles to the body of the mandible and to the mastoid. The contents of the submaxillary triangle are included in the excised block together with the tail of the parotid. The 12th and lingual nerves are not removed, but the lower branch of the 7th nerve is removed.

TREATMENT OF THE NECK IN MOUTH AND LIP CARCINOMA WHEN THE NODES ARE NOT ENLARGED

Though many agree that a block neck dissection is the best treatment when there are enlarged nodes in a patient with mouth or lip carcinoma, there is some difference of opinion in regard to the therapy for a similar patient in whom the nodes are not clinically enlarged. It is thought that the terms "prophylactic" radiation or "prophylactic" neck dissection are not par-

ticularly good ones, as small nodes may possibly harbor small metastases (Table III)

TABLE III

INCIDENCE OF MICROSCOPICALLY POSITIVE NODES FROM PATIENTS
WITHOUT CLINICAL ENLARGEMENT

Author	Pts with Positive Nodes
Kennedy ⁵⁹ (lip)	14%
Simmons ⁵⁹ (mouth)	34%
Morrow ⁵¹ (tongue)	39%
Phillips ⁵⁹ (buccal)	51%

In addition to the microscopic findings listed in Table III, Duffy's report from Memorial Hospital indicates the clinical developments in such patients. In a series of 252 carcinomas of the tongue seen there, 78 had enlarged cervical nodes when first seen. The remaining 174 received no treatment to the neck and during the subsequent period of observation 23 developed inoperable and 48 developed operable cervical metastases.

The choices of treatment when the nodes are not clinically enlarged are radiation, surgery, or the "wait and see" treatment (aptly named by E. S. Meyers⁸⁸).

In these patients about the only form of radiation that is available is external treatment. Figi⁴¹ reported 287 patients with lip carcinomas who had no enlargement of the cervical nodes. Ninety-five patients received no treatment of any kind to the neck, and in this group there were 75 per cent five-year cures. One hundred ninety-two patients received "prophylactic" radiation to the neck, and in this group there were 73 per cent five-year cures. In a large similar group in which neck dissections were done, there were 89.74 per cent five-year cures. Shreiner and Mattick¹⁰⁴ divided their patients with non-palpable cervical lymph nodes into two groups—those with small local lesions and those with large local lesions. In half of each group, no treatment was given, and in the other half of each group extensive cervical radiation was employed. They reported exactly the same percentage of cure in the two halves of each group—85 per cent in each of the small local lesion groups, and 58 per cent in each of the large local lesion groups.

Neck dissection should be the rule to follow in patients with carcinoma of the lip or mouth who have no clinical enlargement of the nodes, as a considerable number of them will have definite metastases, and there is at present no satisfactory way of differentiating them. If any group is to be treated by the "wait and see" method, it is probably safest to do it in very early, low-grade, lip lesions where the incidence of metastases is lowest. Extreme age, poor general health, and ready availability for repeated examinations of the neck may be further extenuating factors, but one should be cautious even with these in omitting dissections in carcinomas of the tongue or floor of the mouth, in which the incidence of metastases is high.

SUMMARY

At the present time, block surgical excision of the lymphatic-bearing areas of the neck gives the best prospect of cure in the greatest number of patients with metastatic carcinoma of the cervical lymph nodes. Lack of clinical enlargement of the lymph nodes does not necessarily mean that no metastases are present, and most of the patients in this group should not be denied the improved prognosis that neck dissection may offer. The operation has a low mortality in itself, and produces a percentage of five-year cures that is worth while.

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CONGENITAL ATRESIA OF THE ESOPHAGUS, WITH TRACHEO-ESOPHAGEAL FISTULAE*

TRANSPLEURAL OPERATIVE APPROACH

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THE EARLIEST RECORD of congenital esophageal atresia is that by Thomas Gibson who, in a book on anatomy published in 1703, tells of observing a case in 1696 and following it to autopsy Mackenzie¹ quotes Gibson's treatise on the case In 1880, Mackenzie found 42 cases in the literature By 1919, Plass,² in an exhaustive review of American and foreign literature, verified 149 cases Rosenthal³ brought the number to 255 cases in 1931, and now there are over 300 cases on file

Vogt,⁴ in 1929, emphasized the need of progress in the treatment of the condition and formulated the first comprehensive classification of esophageal anomalies He divided them into three groups The first is complete absence or agenesis of the esophagus and is quite rare The second group includes those cases which show a blind upper and a blind lower segment neither of which communicates with the trachea The third group includes those anomalies which give fistulous communication to the trachea Type 3A has a blind lower segment but the upper segment opens into the trachea The common Type 3B has a blind upper segment with a tracheal fistula from the lower segment In Type 3C both segments communicate with the trachea Type 3B comprises 70 to 80 per cent of reported cases

The symptoms are constant and diagnostic The infant drools excessive amounts of mucus and saliva He is subject to frequent attacks of choking and cyanosis, and these are precipitated by the taking of fluids by mouth The latter are immediately regurgitated and partially aspirated so that an episode of choking and cyanosis follows each attempt at feeding In Types 1 2 and 3A, a plain film will show absence of gas in the bowel while Types 3B and 3C show its presence

A soft rubber catheter is of considerable diagnostic aid When inserted down the esophagus it reaches an obstruction 10-12 cm from the anterior alveolar margin The inadvisability of use of contrast media, such as barium, is agreed Its use results in overflow aspiration, and an irritative pneumonitis Lipiodol or diodrast may be instilled into the esophagus and a roentgenogram made, but the lipiodol should be immediately aspirated Types 3A and 3C may not otherwise be diagnosed

The anatomy of the condition varies of course with the type of anomaly but in the common Type 3B it invariably shows a constant pattern Plass²

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TRACHEO-ESOPHAGEAL FISTULA

compiled measurements of recorded cases and showed the upper segment to be most frequently 3 to 4 cm in length from larynx to blind end. The fistula opens into the trachea commonly within 1 cm of the bifurcation but may open 2-3 cm above the carina. In a very few recorded cases the fistula opened into a bronchus. The fistulous opening is usually 2-4 Mm in diameter but may be considerably attenuated. The muscular coat of the esophagus may or may not be continuous over the atretic portion. The proximal segment is always dilated and hypertrophied to perhaps four times the size of the distal segment, which usually measures 3-10 Mm in diameter.

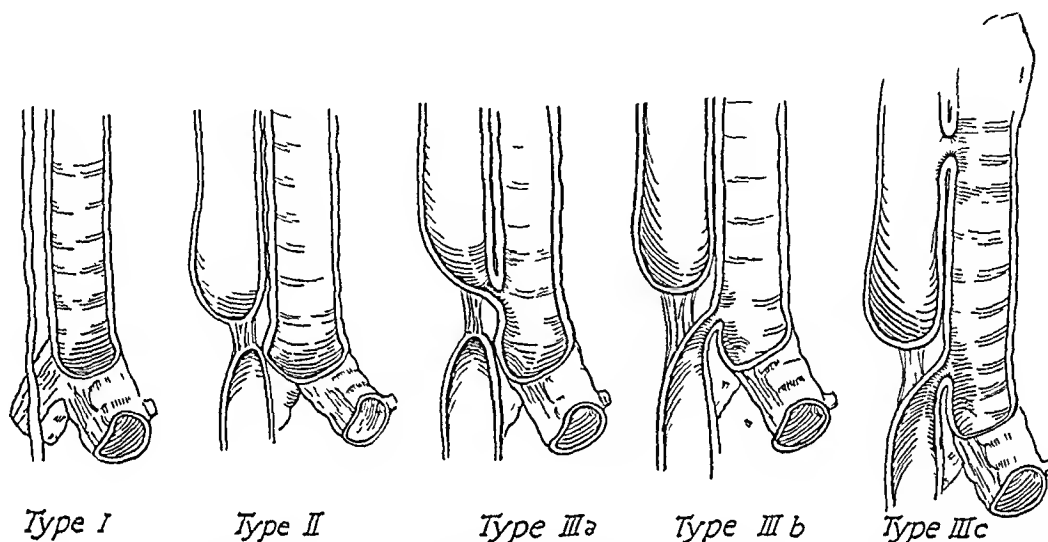


FIG 1—Vogt's classification of congenital atresia of the esophagus and tracheo esophageal fistula illustrated

The normal esophagus below the fistula is 1 cm in diameter. In most cases the segments are separated by a distance of 1 cm but extremes may lap over or be separated 5 cm. There are on record a few cases of very small tracheo-esophageal fistulae in otherwise normal people that were well tolerated into adult life.

Associated anomalies are rather common. Plass² found about half of the recorded cases to show them. Imperforate anus was present in 25 per cent of the cases. In only rare instances are the associated anomalies incompatible with life.

The embryologic explanation of esophageal anomalies is a much confused subject. The normal pulmonary anlage differentiates from the primitive foregut as a tiny, ventrally placed mass of entoderm seen first in the 3 Mm embryo just caudal to the pharyngeal pouches. By the 4 Mm-stage the anlage has grown in a caudal direction so that two lateral longitudinal grooves are formed in the wall of the foregut and their internal elevation is a septum which begins to separate the foregut into a posterior gullet and an anterior trachea. The separation is complete at the 11 Mm-stage.

Just why the separation of the trachea from the foregut should result in atresia and fistula in some cases is an enigmatic problem. The constant pattern of the anomaly makes any theory of chance embryonic infection or trauma untenable and one looks to an early (before 11 Mm) alteration

in the growth process for the explanation That the change may be genetic is evidenced by Mackenzie's case, where a man fathered three infants, all with the anomaly, by different wives

Three theories usually are given to explain the anomaly The esophagus is, at one stage of its growth, a solid bar of tissue Cessation of growth at this stage would result in a condition simulating atresia This theory is untenable because the solid bar stage does not appear until the 20 Mm -stage, after the esophago-tracheal anlage is well formed (4-6 Mm)

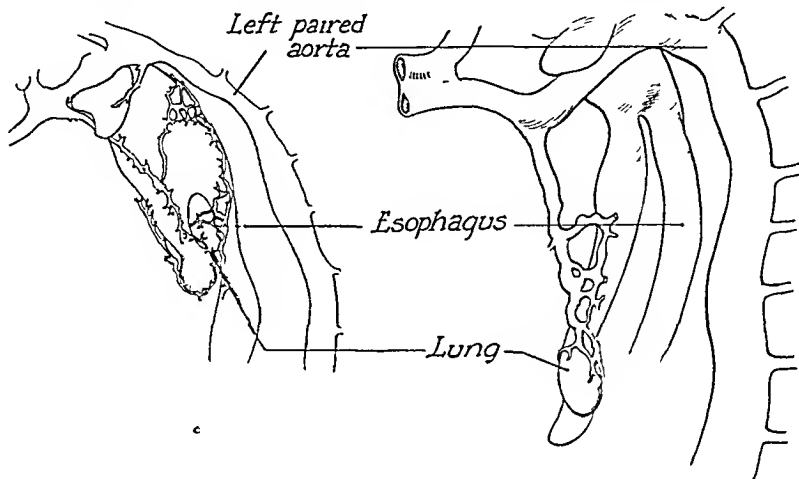


FIG 2 —Drawing showing embryologic development of esophagus and trachea in (a) 4 Mm embryo and (b) 11 Mm embryo (modified and from Rosenthal)

The second theory assumes that the lateral septa deviate posteriorly to fuse with the dorsal wall of the foregut resulting in an atresia Failure to fuse one lateral septum with its mate would conceivably result in a fistula Deviation of the septum could be brought about by variations in pressure within the embryo by an enlarged heart, anomalous vessel, *etc*

Rosenthal³ believes the crux of the explanation to lie in altered cell growth along the lateral septa and not on mechanical deviation Thus, deficient or absent growth of the septa would result in fistula while deficient growth of entodermal cells of the dorsal wall of the foregut would result in atresia of the esophagus The earliest known simple anomaly of this type is in an 18 Mm -embryo in the Harvard collection

The trends of surgical treatment of esophageal anomalies are mirrors of surgical and anesthetic progress as a whole If untreated these unfortunate infants rapidly lose 25 to 40 per cent of their weight, according to Brenneman,⁵ and die almost routinely within one week Attempts at feeding by gastrostomy were common from the time that Charles Steele⁶ first performed gastrotomy on a case in 1888 This method and jejunostomy, which was advocated by Brenneman⁵ in 1913, were unsuccessful because the stomach contents invariably regurgitated into the lung *via* the fistula Richter,⁷ in 1913, advocated ligating the fistula transpleurally and gastrostomy with repair of the esophagus at a later date These cases were failures because regurgitation occurred from the blind proximal segment Von Hacker,⁸ in 1926

advocated use of the Murphy button to form a direct anastomosis, but was never successful

Mixer⁸ realized, in 1929, the failure of gastrostomy as a treatment and began using a cervical esophagostomy combined with extrapleural ligation of the fistula and exteriorization of the distal segment as a dorsal esophagostomy. By 1936 he had decided that this method was a failure and turned to a more direct approach

Leven,⁹ in 1936, advised exteriorization of the cardiac esophagus and stomach and gastrostomy in the distal portion of the stomach but abandoned the method in 1940¹⁰ in favor of a long range four-stage attack involving

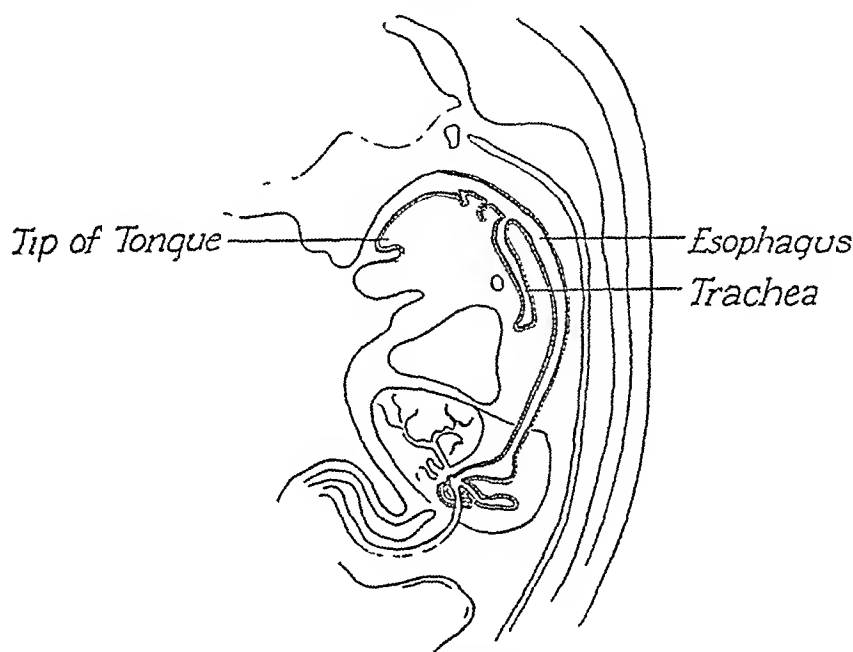


FIG 3—Stage of development of the esophagus and trachea in a 17 Mm embryo (modified and from Arey)

first, gastrostomy, second, extrapleural ligation of fistula, third, cervical esophagostomy, and fourth, antethoracic esophagoplasty at a later date. He had an infant upon whom he had performed the first three stages alive one year and seven days at time of publication

Gage and Ochsner,¹¹ in 1936, recommended cervical esophagostomy and ligation of the cardiac esophagus and gastrostomy. This allowed accumulated secretion of the distal esophageal segment to overflow into the trachea, and was unsuccessful

Gamble,¹² in 1938, suggested a method, similar to Leven's, in which he divided the cardiac end of the stomach leaving the proximal end open for drainage of the distal segment of the esophagus and performing a gastrostomy in the distal stomach. A cervical esophagostomy was also established

Carter,¹³ in 1941, advocated an indirect approach, wherein he performed a cervical esophagostomy and then by abdominal operation exposed the cardiac esophagus and pulled down as much as possible of it before placing a ligature about the esophagus and dividing it bringing out the distal segment of an antethoracic esophagostomy. His patient lived 62 days

By 1936 the failure of the indirect approach to the problem had become

evident, and burdened with the added problem of antethoracic cutaneous esophagoplasty, it has been criticized by many surgeons. Lanman⁸ began performing primary anastomoses by the extrapleural route in Boston in 1936. All of his patients succumbed, but two lived eight and nine days, respectively.

Haight and Townsley¹⁴ have recently reported a successful extrapleural anastomosis with the child then two years of age, which, so far as I know

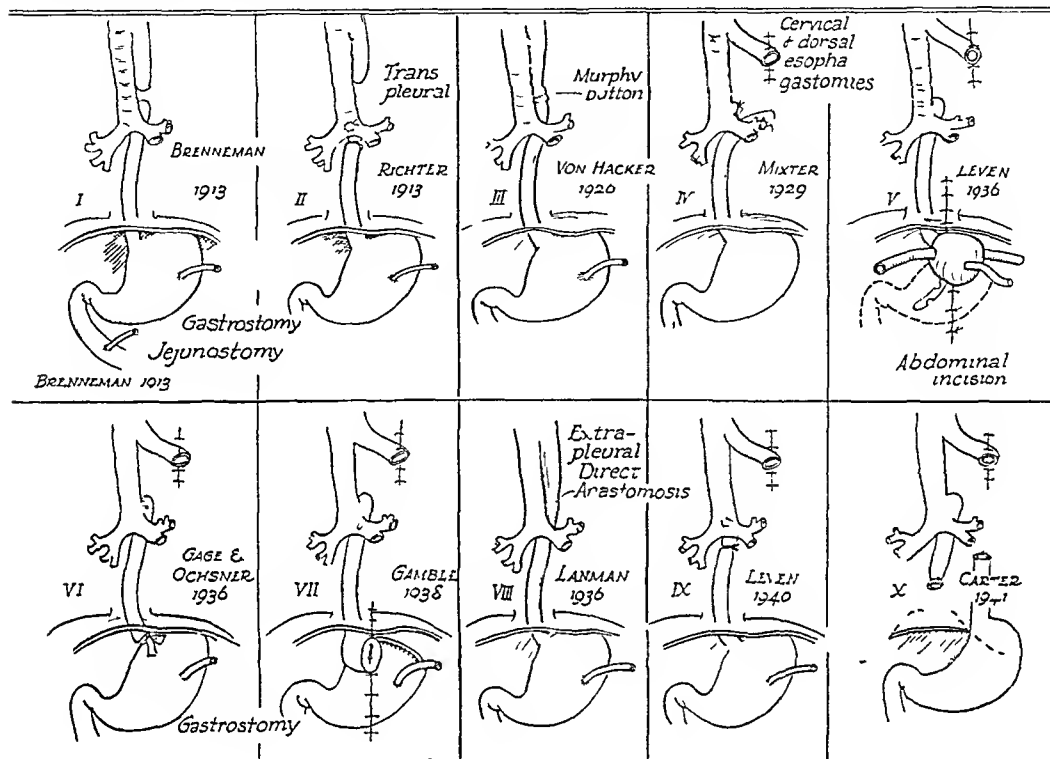


FIG 4—Types of operative procedure utilized or proposed in the treatment of tracheo-esophageal fistula

is the only successful case of restoration of the esophagus, and the patient survived that long. It is true that there was not a primary union of the anastomosis since the wound broke down, and an esophageal fistula developed which subsequently closed spontaneously. The trend has been more and more to primary anastomosis and several technics have been advocated. Lanman and Mixer,⁸ Leven,^{9, 10} Haight,¹¹ and Shaw and Sampson^{15, 16} practice an extrapleural approach to the lesion, while Richter,⁷ Churchill,⁸ and the authors, advocate a transpleural approach. Sampson and Shaw suggested, in 1938, that anastomosis is easiest over a rubber urethral catheter size F 12 to F 15.

Four of these unfortunate children have been treated in the John Sealy Hospital during the past three years.

CASE REPORTS

Case 1—Male, with a tracheo-esophageal fistula, Type 3B. On August 4, 1940, the third day of life, a gastrostomy was performed. The child lived 48 hours, and died of bronchopneumonia.

Case 2—R. E. W., male. Type 3B. This child was operated upon by Dr. E. J. Poth August 14, 1942, the seventh day after birth. Posterior extrapleural operation, in which the esophageal fistula was ligated. The child lived for three days.

Case 3—This was the first child operated upon transpleurally. The success of this procedure prompts us to report it in detail.

D G H, male, born at St. Mary's Infirmary, March 28, 1943, weighing 7 lb 8 oz. On the fourth day a diagnosis of atresia of the esophagus and tracheo-esophageal fistula was made roentgenologically, showing the presence of gas in the stomach and intestines. A barium mixture was used to outline the proximal esophagus. It was thought to be Type 3B (Fig. 5). Parenteral fluids were given, with repeated transfusions. Because



FIG. 5—D G H showing gaseous distention five days after birth.

of the failure of surgical treatments in previous cases the pediatrician in charge had little hope of relief for the child. On the 14th day surgical consultation was had with one of us, and we offered little encouragement from surgery, with no recorded cases of cure, to our knowledge, at that time. Because the parents insisted that some effort be made, surgical relief was attempted. Though the child was 15 days old and had had nothing except parenteral fluids, with blood, it seemed in fair condition.

Our plan of treatment was determined largely by our experience with resection of the middle portion of the esophagus for carcinoma, and with the impression that intrapleural operations are tolerated much better than is generally thought. We decided to approach the esophagus transpleurally, hoping to be able to close the fistula and effect an end-to-end anastomosis of the esophagus. If the anastomosis was not possible, we planned to close the lower end of the esophagus and bring the upper segment out the neck, as is done after resecting the esophagus for cancer, later dealing with the problem of an extrathoracic esophagus.

Operation—April 12, 1943 Under local anesthesia, a gastrostomy was performed. Air but no fluid was in the stomach. The gastrostomy tube was left open to keep the stomach empty of air and prevent any regurgitation up the esophagus during the operation. The child was given a general anesthetic and placed on his left side, then an incision was made in the 5th intercostal space from near the vertebra to the sternum in front. The ribs were spread apart with a Gelpi retractor, the lung collapsed by compression and retracted forwards and downwards. The defect in the esophagus was



FIG 6—Baby L showing gas in intestines and lipiodol outlining blind proximal esophagus

easily recognized beneath and slightly above the crossing of the azygos vein. The azygos vein was doubly ligated and severed. The pleura was incised over the esophagus, above and below. A ligature was passed beneath the esophagus above and below the defect. These were used for traction. The esophagus was lifted out of its bed in the defective area, leaving the lower end attached to the trachea by the fistulous communication. The lower segment narrowed gradually to the fistula and here was about 5 Mm in diameter. A fine silk suture was passed through the fistula, near the trachea, and then a narrow clamp was applied a short distance away from the trachea and the fistulous tract cut across. The tracheal side of the fistula was closed with the suture previously introduced.

At this time the question arose as to whether or not our original plan of closing the lower end of the esophagus and bringing the blind end up through the neck should be attempted. To subject an older person with carcinoma of the esophagus to a cervical esophageal fistula seemed quite all right, but to subject a young child to a fistula with the prospects of going through life with some type of an extrathoracic esophagus seemed hardly justifiable, even though a life might be saved.

After liberating the esophagus almost to the diaphragm, being careful not to sever the circulation to the esophagus on its vertebral side, and also freeing the upper end of the esophagus high up into the neck the two ends apparently could now be approximated.

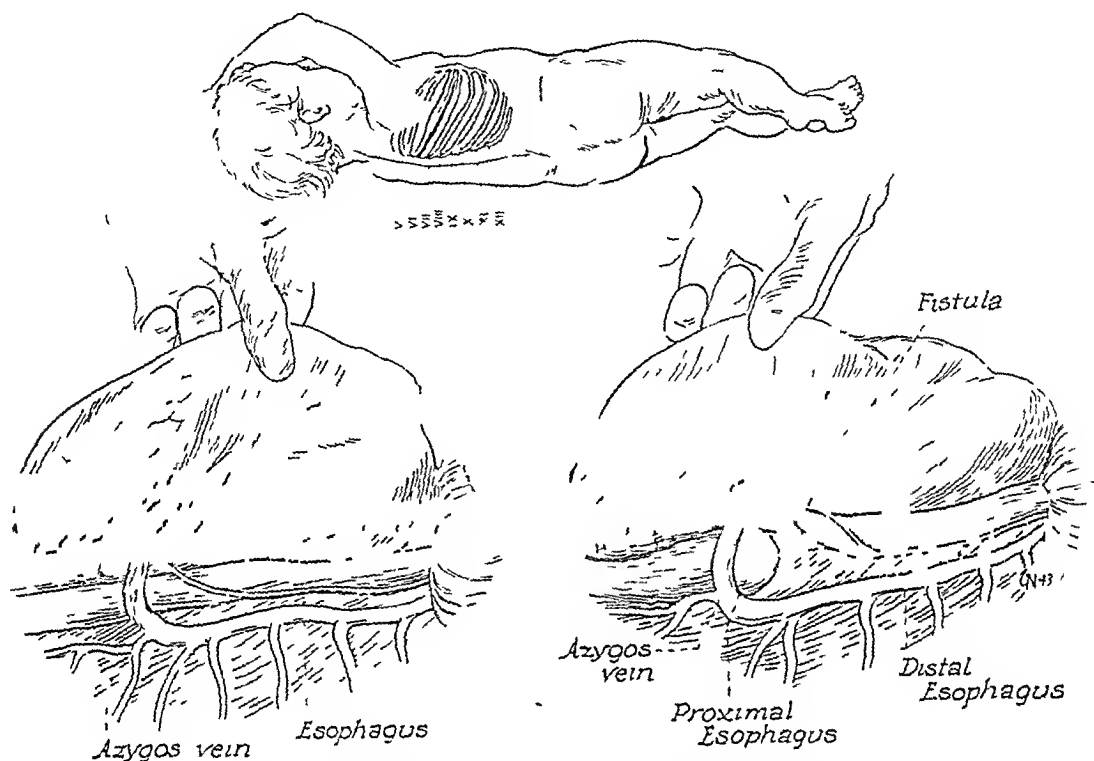


FIG 7—Transpleural approach (a) Incision in the 5th intercostal space (b) Position of esophagus (c) Illustrating deformity in D G H before anastomosis

for an anastomosis. This liberation seemed to give at least 1–2 cm more length and the circulation of the two ends seemed adequate. The opening in the lower segment was enlarged to about 0.6 cm. A No. 7 ureteral catheter was passed through the nose down into the upper blind segment of the esophagus outlining its lowest part. This end was opened for a distance of about 1 cm over the point of the catheter. The catheter was passed on into the lower segment and into the stomach. The catheter served to define the lower end of the upper segment and was left in the stomach so that it may be recovered from the gastrostomy opening and serve to pass a string through the esophagus for dilatation to prevent stricture. The two ends of the esophagus were sutured together over the catheter with a continuous No. 000 chromic catgut (made on needle) suture "eye suture." The stitch was a continuous running stitch interrupted by locking on opposite sides of the esophagus. The anastomosis seemed to be secure with this stitch (Fig. 7). To relieve tension on the suture line, two stitches above and two stitches below were inserted passing just through the muscular coat of the esophagus and anchored to the pleura. The lung was then expanded by massage and intratracheal pressure. The chest wall was brought together with interrupted No. 0 chromic sutures passing above and below the adjacent ribs. The muscles were carefully sutured together as well as the skin. An extra effort was made to have the lung completely expanded when the airtight closure was made (Figs. 8 and 9).

The patient's convalescence was smooth, showing very little shock. He was kept

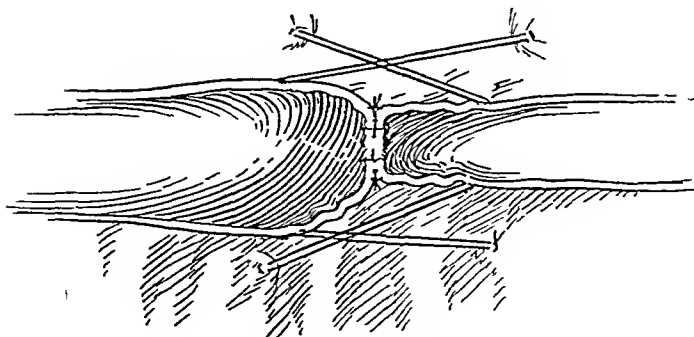


FIG 8—Stitches applied subsequent to anastomosis to relax tension on suture line

in an oxygen tent for ten days. Transfusion was given subsequent to the operation and also parenteral fluids for several days. The ureteral catheter was fastened in place and allowed to remain for a period of 12 days when it was recovered from the stomach



FIG 9—D G H postoperative roentgenogram showing ureteral catheter through the esophagus and gastrostomy tube in place

through the gastrostomy opening under the fluoroscope and a large braided silk thread was pulled through the esophagus and out the gastrostomy opening, the two ends of the string being tied together. The purpose of this thread was for bougie dilatation of

the sutured area to prevent stricture After a period of three weeks bougies were passed at intervals, and size No 18 passed easily (Fig 10)

Though bougies passed easily through the anastomosis, still the child had difficulty in taking nourishment by mouth, the effort being accompanied by some strangulation and coughing, and, as has been previously stated, on several occasions he developed high temperature with physical signs of pneumonia, usually in the left lung, as confirmed roentgenologically By stopping mouth feeding and substituting gastric feeding and the administration of sulfonamides, he recovered and proceeded to gain weight

When the child was about seven months of age someone inadvertently cut the string which was used for dilatation It might have been possible to leave it out at this time but thinking further dilatation might be necessary, one of us attempted to replace the string A very small piece of lead was placed on the end of a thread and brought from the mouth through the nose, the leaded end being left in the pharynx with the idea that the thread would be passed into the stomach where it could be recovered and the large string replaced Two days subsequently a roentgenogram showed the piece of lead at the upper end of the esophagus (Fig 11) We attempted to withdraw it but were surprised to find it held fast Several attempts were made to pull the thread back but it would not give way Then the thread was cut off, allowing it to go into the pharynx, hoping that the lead would pass on into the stomach Then we passed the ureteral catheter through the nose into the stomach and recovered it as we had before replacing the string

Following this the child seemed to have difficulty swallowing and had repeated attacks of strangulation A week later he developed an active pneumonia from which he died on November 14, 1943, age seven months and 21 days

Autopsy revealed the lung firmly adherent to the pleura throughout the right side of the chest, the left pleural cavity being free of adhesions Union of the esophagus was excellent, with an opening 1 cm in diameter (Fig 12) But to our surprise there was an opening between the trachea and esophagus at the level of the cricoid cartilage, and the thread with the piece of lead attached was fastened in a very complicated way through the fistula and around the cartilage The explanation for this situation was very puzzling We were at a loss to explain how such a small piece of lead could perforate through the tracheal and esophageal walls but a more careful examination showed



FIG 10—D G H postoperative roentgenogram showing ureteral catheter through the esophagus and gastrostomy tube in place



FIG. 11.—D. G. II, postoperative three months with tracheostomy tube and string for dilatation through the nose, esophagus and stomach, and on tracheostomy opening.

there was a vertical communication 1 cm long just below the cricoid cartilage. Upon examining the specimen more closely, one end of this tear for a distance of 4 Mm was evidently another congenital fistula (Figs 13 and 14). We feel quite confident that this second fistula was present all the time, and that this piece of lead passed through this fistula and became entangled, resulting in further enlargement of the fistula and subsequent death of the child. The explanation of the difficulty of swallowing, with repeated attacks of aspiration pneumonia during his convalescence, can be explained satisfactorily by the finding of the second tracheal fistula in the upper segment of the esophagus. This would place this case in Vogt's classification of Type 3C. The undiagnosed fistula being high in the neck could have been easily closed if it had been diagnosed.

Case 4—This was a female, Baby L, born November 6, 1943, and operated upon the third day after birth. This child was premature, weighing only 5½ lb and was very weak (Fig 15). It also had a deformity of the rectum in which the rectum opened into the vagina. Any operative treatment seemed very hazardous. A transpleural approach was made and the Type 3B deformity was found. The azygos vein was ligated. The communication of the lower end of the esophagus was just at the bifurcation. The blind upper end of the esophagus was high, some 3 cm distance between the two ends. The fistulous tract was ligated with silk and an effort made to approximate the



FIG 12—D G H showing small piece of lead fastened in upper esophageal fistula

two ends of the esophagus. Because of the distance in the very small child and the very small structure, this was impossible. In an effort to secure more length, the esophagus was liberated from the diaphragm and the stomach pulled partially through the opening. Even this did not give sufficient length. Further effort was made to fix a bile duct vitulum tube into the gap between the two ends. The tube was more than one inch long, but it was too short to bridge the gap. After the excessive amount of trauma, the only alternative left was to bring the upper end of the esophagus up through the neck and close the lower end, and this was done. In addition, a gastrostomy was performed with a No 14 rubber catheter. The child lived 12 hours.

The operation was unnecessarily long and the child might have lived if our judgment had been better and we had performed a cervical esophagostomy in the beginning.

DISCUSSION—In an effort to save the lives of these unfortunate children, many plans have been devised for surgical treatment, all of which have been rather universally unsuccessful. They occur sporadically and few surgeons have an opportunity to treat a large number. It is self-evident that after

closing of the tracheal fistula the restoration of the esophagus is of extreme importance. There is no satisfactory substitute for the esophagus even though many attempts have been made to construct one. To condemn a child to a life with an artificial esophagus is a grave responsibility and may not be

FIG 13

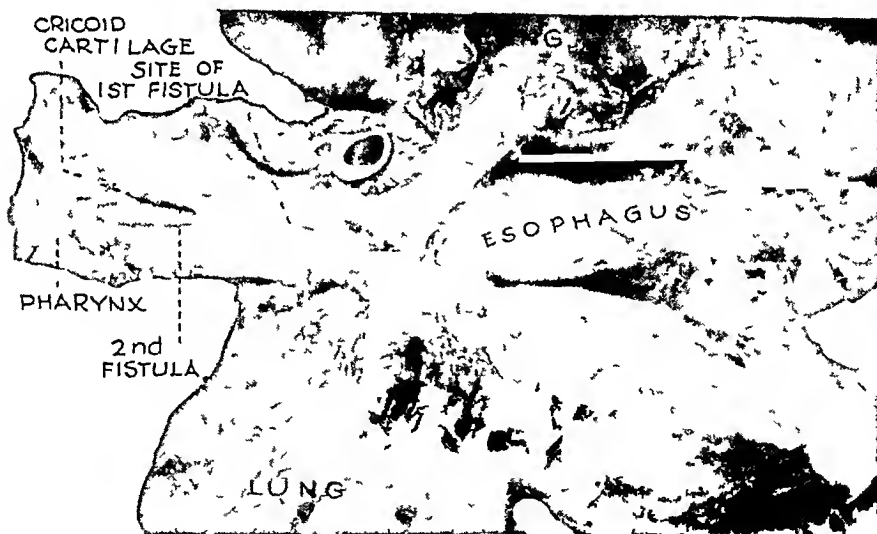
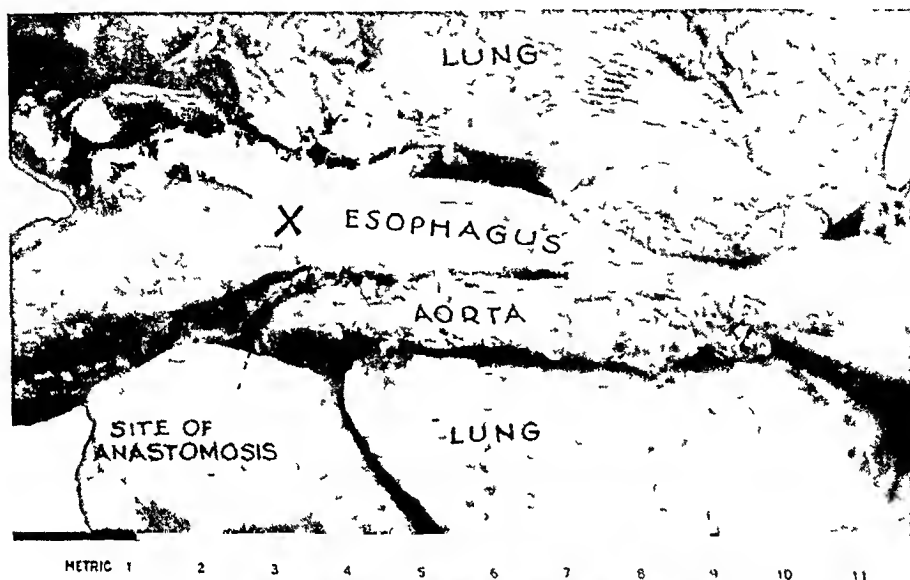


FIG 14

FIG 13—Autopsy specimen Esophagus from behind (X) Anastomosed area
FIG 14—Autopsy specimen Anterior view of trachea opened down to bifurcation, showing site of fistula and site of second fistula

justified. Efforts heretofore to restore the esophagus have been made extrapleurally and with one exception they have all failed (Haight¹⁴). With this information in mind the transthoracic approach to the pathology was decided upon and I think the results justified the assumption that it is a preferable route. Opening of the thorax is probably a less severe procedure than the operation which is done extrapleurally and it can be done more quickly

In the latter procedure infection invariably occurs and tearing of the pleura with its accompanying consequences is difficult to avoid. One can much more easily liberate the esophagus and get the ends closer together through the transpleural approach, but the greatest advantage, I am confident, is that the chance of union of the anastomosis is much greater with the transpleural operation than with the extrapleural. When the lung is expanded following anastomosis the sutured area is thoroughly splinted by the visceral pleura of the expanded lung and within a very short time is firmly sealed off by pleural adhesions. This results in the anastomotic area being soon reinforced with collateral circulation, making union much more certain than it would be with an anastomosed esophagus left in the dead spaces of the extrapleural wound which will naturally fill with blood clot. Taking advantage of the principles used in intestinal suturing of depending upon the power of the peritoneal surfaces to become rapidly adherent should not be

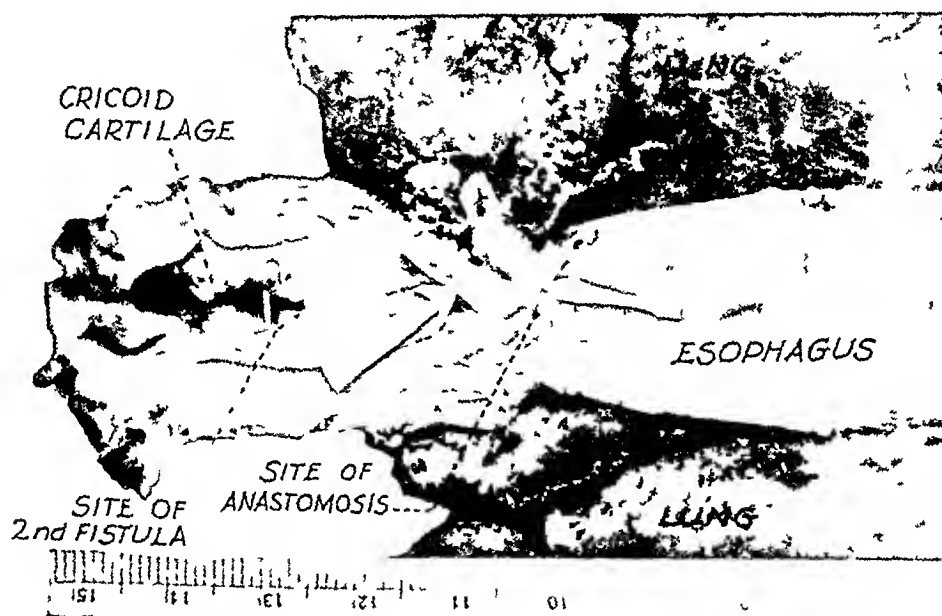


FIG 15—Posterior view of esophagus opened showing (a) site of anastomosis (b) second fistula with tearing due to lead and thread

overlooked in the pleural cavity. Pleural surfaces have this power of adhesion and also the power of resisting infection just as peritoneal surfaces have. We can depend upon the expanded lung forcing the visceral and parietal pleural surfaces in contact with the esophagus to further assure sealing off of the sutured lines and assuring union. Certain cases will not lend themselves to primary anastomosis, particularly if a distance of over 2 cm separates the upper and lower esophageal segments. Only in these cases should the indirect attack be used. We believe that every case should be explored transpleurally, with ligation of the fistula and a primary anastomosis if technically possible. If the two esophageal segments are too widely separated the fistula should be ligated, and a cervical esophagostomy and a gastrostomy performed. In this indirect approach the antethoracic cardiac esophagostomy of Carter¹³ appears particularly attractive for this procedure as it would shorten considerably the length of cutaneous esophagoplasty necessary at a later date,

but it is not wise to attempt this procedure at the primary operation. We are strongly of the opinion that the above reasons are sufficient to recommend the transpleural operation over the extrapleural.

CONCLUSIONS

The history of congenital esophageal atresia and tracheo-esophageal fistula is one of long and repeated failures in efforts which have been made to solve the problem. A partial solution seems near if an early and accurate diagnosis should be made. Time should be taken to prepare the patient for operation even though this may take several days. Transpleural approach to the deformity does not carry great hazards as are usually attributed to it but it does give one a much better opportunity of relieving the condition than the extrapleural approach. Our experience leads us to believe that a primary anastomosis of the two segments of the esophagus can be made in many instances, and this, by all odds, is the most desirable. When the lengths of the segments will not permit anastomosis, cervical esophagotomy and occlusion of the lower end is the next alternative and in either instance, a preliminary gastrostomy should be done.

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DISCUSSION—DR ALFRED BLALOCK, Baltimore, Md This paper by Doctor Singleton is quite interesting It is extremely unfortunate that this child should have been lost after having done so nicely for a number of months following this difficult operation I am sure Doctor Singleton will be the first to admit that he was fortunate in having a patient with atresia of the esophagus who was in good condition at the time of operation, which was not performed until 16 days following birth He was fortunate also in that the esophagus was long enough for a primary anastomosis between the two ends Unfortunately, such is not always the case The reason for my discussion is to raise the question as to whether one is warranted in attempting a primary anastomosis

I would like to show Doctor Singleton's first slide As he stated, the most common type of abnormality is that in which the upper end of the esophagus ends blindly and there is a communication between the lower end of the esophagus and the trachea Approximately 14 months ago I saw a newborn infant with this type of abnormality, and carried out the procedure described by B N Carter, which is a modification of that described by Ochsner and Gage Under local anesthesia, the upper end of the esophagus was brought out through an incision in the neck An abdominal incision was then made under local anesthesia, the esophagus was doubly ligated at the diaphragm and the lower end of the esophagus was anchored to the skin of the abdominal wall This left a short segment of the esophagus in communication with the trachea The question arose as to whether or not the child would have difficulty as a result of this communication and I can only say that there has been no evidence of this as yet Doctor Longmire and Doctor Ravitch have not as yet completed the reconstruction of a tube, but the child is in excellent condition Some months ago Doctor Reinhoff had a similar case and the procedure which was performed differed only in that the vessels at the upper end of the stomach were divided, and this allowed Doctor Reinhoff to place the upper part of the stomach beneath the skin of the anterior wall of the chest As a result of this latter maneuver the defect which needs to be bridged by some sort of plastic procedure is only several inches in length

Despite the encouraging results which have been reported by Doctor Singleton, Doctor Haight, and others, I am inclined to believe that one should use a multiple-stage type of reconstruction for atresia of the esophagus rather than a primary anastomosis between the two ends of the esophagus The procedure described by Doctor Carter can be performed quickly under local anesthesia, and it is my impression that there will be more survivals when this type of operative therapy is carried out than when a primary anastomosis is performed I realize in saying this that the ideal type of operation is that which Doctor Singleton is describing

DR ALTON OCHSNER, New Orleans, La The importance of this subject is not appreciated Doctor Gage, a number of years ago, emphasized early diagnosis Until we can get obstetricians cognizant of the fact that it is a matter of early diagnosis we cannot do much about correcting it Doctor Gage suggested that every baby should have a catheter passed into the esophagus at the time of birth in order to detect a possible obstruction He insisted on this being done in his own children

Whereas the usual anomaly is an esophageal atresia combined with a tracheo-esophageal fistula, other types do rarely occur, as shown by Doctor Singleton Recently, we have had a patient who had no atresia but who had two fistulae between the esophagus and the trachea Unfortunately, only one was recognized antemortem, only one was closed

I must disagree with Doctor Blalock that relief of the atresia is not necessary We are convinced that the accumulation of salivary and other secretions in the blind pouch results in spillage into the trachea, predisposing to bronchitis and bronchiectasis Even though the reconstructive procedure is one of considerable magnitude in such a young infant, it is unquestionably the best method of therapy

Although Doctor Singleton operated upon his patient through the right hemithorax

he did not emphasize the desirability of this approach, which I think is extremely important. Cameron Haight, of the University of Michigan, has operated upon a large number of these, I believe about 20, and according to his published reports, he has explored them all through the left hemithorax. From our experience with extripation of the esophagus for carcinoma, we are convinced that the approach from the right side is preferable to that on the left. We have done the reconstructive procedure in three patients with esophageal atresia and tracheo-esophageal fistula, two of whom were operated upon through the left hemithorax and one through the right. One operated upon through the left hemithorax was accomplished relatively easily. The other was extremely difficult, however, because of the fistula beneath the arch of the aorta. Although we attempted, as Haight suggested, to mobilize the aorta by ligation of the first intercostal artery this did not give sufficient room to facilitate the anastomosis. Since the esophagus is more on the right than on the left in this area, we believe that the approach from the right side is preferable to that from the left, and in the one case which we operated upon through the right hemithorax the procedure was relatively simple.

I think it is perfectly remarkable that Doctor Singleton was able to accomplish what he did in his case after 15 days, because most of the patients with this condition die as a result of aspiration pneumonia. It is for this reason that the diagnosis must be made early, before the aspiration has occurred and at a time when something in a curative way can be accomplished.

DR A. O. SINGLETON, Galveston, Texas (closing). I will admit that I am an amateur and, so far as I know, there are no experts upon this particular condition. The Boston Children's Hospital has had the greatest experience, they report some 31 patients operated upon, with a mortality of 100 per cent. I am of the opinion that it is hard to construct an artificial esophagus and make it work. I have tried some of them and did not succeed. To subject a child to a cervical fistula until you get the esophagus fixed is serious. The only way you can be sure you can do an anastomosis is by transpleural approach. One can still, if necessary, do a cervical esophagostomy in addition to closing the fistula.

Doctor Blalock's method, from the standpoint of saving life, may be a little safer, but the final outcome is not settled. One has a cervical fistula left and must depend upon making an esophagus at a later time, which is still a difficult undertaking.

CHRONIC CYSTIC MASTITIS WITH PARTICULAR REFERENCE TO CLASSIFICATION¹

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ALTHOUGH there is fairly complete agreement that chronic cystic mastitis is not an inflammation of pyogenic origin, yet the actual pathogenesis of the disease is poorly understood. However, in view of clinical and experimental observations with various sex hormones during the past several years, it appears that the disease may be related to an insufficiency or an excess of certain hormones, thereby suggesting that the disease is of endocrine origin.

CLASSIFICATION

There is, likewise, no agreement as to a method of classification of the various types of the disease, although various authors have suggested certain ways of classifying the various lesions encountered. We wish to make a strong plea for a classification which would be of clinical as well as pathological significance. The importance of this dual consideration is emphasized by the fact that certain types of chronic cystic mastitis may develop malignant characteristics. The experiments of Loeb,¹ Lacassagne,² and others, proving the development of carcinoma in the mammary glands of animals following administration of certain hormones, actually suggest the relationship of hormone imbalance to the development of carcinoma. However, since the amount of hormone required to produce carcinoma in their experiments was quite large, we cannot assume with any degree of certainty that such a relationship would exist in the human being.

We wish to present a classification of the various types of lesions, which is based chiefly on two factors: (1) The predominance of the pathologic lesion present, and (2) the relative danger of transformation to carcinoma. This classification includes four major groups as listed below:

Group 1 Adenofibrosis—The essential lesion is a fibrosis which is relatively diffuse throughout the breast.

Group 2 Benign Parenchymatous Hyperplasia—There is a proliferation of the glands and ducts, but no changes resembling malignancy or malignant tendencies. Secretory products accumulate in the dilated ducts.

Group 3 Precancerous Hyperplasia—There is an advanced proliferation of cells (chiefly of the ducts), which reveal plication, layering, and increase in mitoses. The shape of the cells is atypical and variable. Many nuclei are hyperchromatic. There is a distinct resemblance to a malignant process although actual invasion is not seen.

¹Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

Group 4 Cystic Disease—Cysts are the predominant lesion although occasionally a large one (of the blue dome variety) may be found. There are usually several cysts. No epithelial hyperplasia is encountered.

TABLE I

RELATIVE INCIDENCE OF THE LESIONS ENCOUNTERED IN 76 SUCCESSIVE CASES OF CHRONIC CYSTIC MASTITIS OBSERVED AT ILLINOIS RESEARCH HOSPITAL

	Incidence	Average Age of Patients
Adenofibrosis	22%	37 4 years
Parenchymatous hyperplasia	46%	43 7 years
Precancerous hyperplasia	22%	41 6 years
Cystic disease	10%	46 4 years

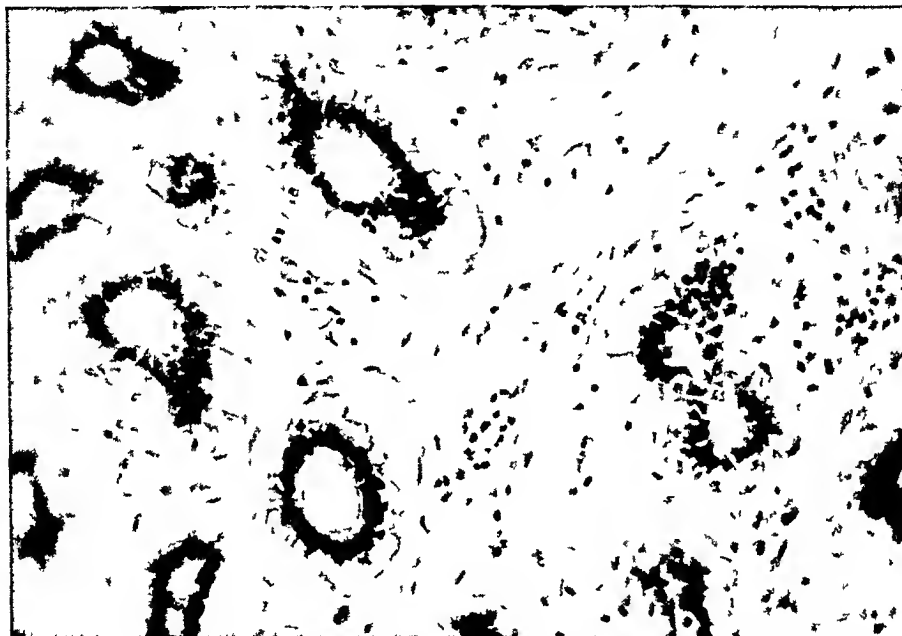


FIG. 1.—High power of the early stage of adenofibrosis. Note that the glands are relatively normal, but edema of the interstitial tissue is present along with deposition of histiocytes and young connective tissue cells. Later, the edematous tissue will be replaced with adult connective tissue with "smothering" of the glands as in Fig. 2.

We wish to emphasize that only on rare occasions will the lesion consist entirely of one of the four types described above. Occasionally, cases are encountered in which all four types of lesions may be found. However, with few exceptions, one of the lesions will be found to predominate. Since there is frequent blending of the various lesions, an accurate mathematical division will not be possible. The figures presented above, representing 76 cases of chronic cystic mastitis operated upon at Illinois Research and Educational Hospital during the past seven years, may be different from those encountered in a private hospital because our hospital is a charity institution in which perhaps a more advanced stage of certain disease processes will be encountered. This might account for the relatively high incidence of precancerous lesions. We wish to emphasize very emphatically that the lesion which we have designated as precancerous is not necessarily going to terminate in carcinoma. There is no invasion; we, therefore, wish to emphasize that it

is still a benign lesion, which does not require radical treatment, however, simple mastectomy as discussed later is usually indicated so that all of the dangerous areas are removed. We have estimated that if lesions were untreated, the possibility of development of cancer in each of the four groups would be somewhat as follows

Adenofibrosis	0%
Benign parenchymatous hyperplasia	3 to 10%
Precancerous hyperplasia	20 to 30%
Cystic disease	2 to 4%

Obviously, there is no way of determining the probability of development of carcinoma since surgeons remove all the lesions which are of the suspicious type. Removal of the lesion eliminates the possibility of carcinoma unless the excision is inadequate. As a matter of fact, we have observed development of carcinoma in precancerous hyperplasia treated by inadequate local excision. It should be emphasized that proper excision will reduce the possibility of malignant transformation to a minimal figure, but will preclude accurate estimation of the dangers associated with the respective lesions.

Semb³ has classified chronic cystic mastitis into two groups: (1) Fibro-adenomatosis simplex (microcystica), and (2) fibro-adenomatosis cystica (with macroscopic cysts). He indicates that carcinoma may develop in such lesions, and remarks that in his series the frequency was 2 per cent in the former group and 24 per cent in the latter group.

PATHOLOGY

The four groups of lesions described below represent the four major pathologic changes observed in chronic cystic mastitis. Although more than one type of lesion is frequently encountered in the same breast, with few exceptions one of the four predominates.

1 *Adenofibrosis*—In these lesions replacement of the breast by connective tissue forms the salient feature. The connective tissue appears to be laid down to replace a periglandular edema, seen best in the earlier cases. By proliferation the connective tissue comes to surround the glands and infiltrate between them. This process results in a fibrous stroma which breaks up the normal lobule arrangement and converts the breast to a markedly fibrous structure. We do not know the pathogenesis of this lesion. We do know that only a part or all of the breast may be so altered. We, likewise, know that it may occur at any age and thus it is possibly due to several sets of factors which could excite the connective tissue elements to overgrow the epithelial.

In the early stages, the breast presents a tense, moderately increased consistence upon palpation. The parenchyma feels indurated and rubbery firm. The superficial surface may be somewhat granular because of minute nodules. This is produced by infiltration of the ends of Cooper's ligaments by the connective tissue (Cheate and Cutler⁴). True nodularity as generally considered in breast lesions is produced by cysts and these do not form a prominent feature in typical adenofibrosis, hence will not be a common finding. In

the later phases the breast palpates as a solid mass, uniformly of firm rubbery consistence

The *gross pathologic* findings upon sectioning through such a breast consist of a generalized increase in parenchyma which is characteristically ivory-white in color. The apparently increased parenchyma is a relative feature, as it is more a feature of prominence rather than amount since most cases of adenofibrosis occur in rather small breasts. Firm, elastic, ivory-white tissue may be found to replace parts or all of the breast according to

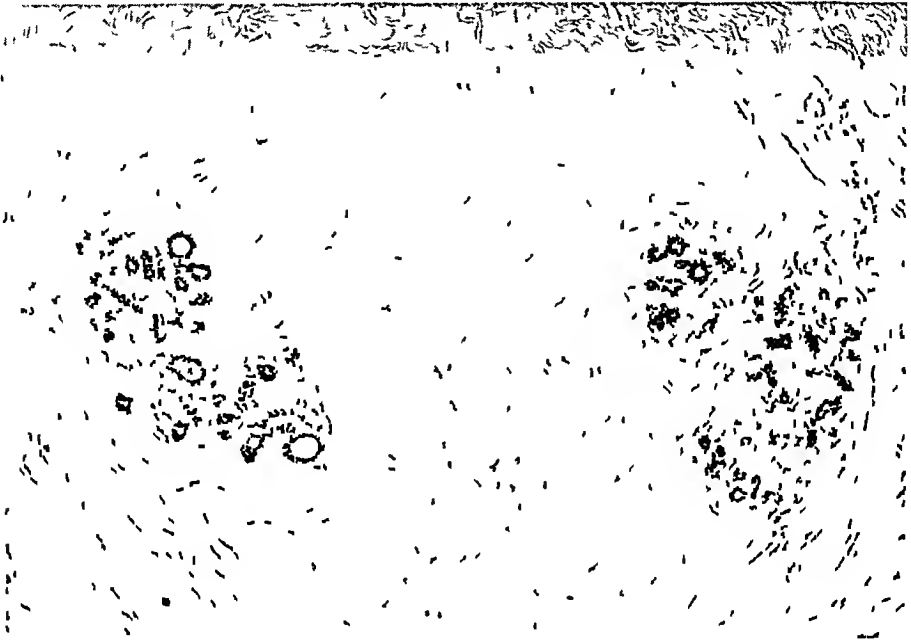


FIG. 2—Advanced stage of adenofibrosis, illustrating a marked preponderance of fibrous tissue with a paucity of glands, the cells of many of which are showing degenerative changes

varying involvement. Permeation into the marginal ligaments may produce a false lobulation of the superficial fat. At times the cut surface will reveal minute gray-pink specks. These represent areas of glandular hyperplasia, and are usually obliterated by the overgrowth of connective tissue. Cystic spaces are uncommon findings, and usually do not attain significance in either size or numbers in typical cases of adenofibrosis. Occasionally small cysts of a few millimeters size are encountered, however. These occur as sharply outlined spaces (actually only a simple dilatation of ducts), and contain a small amount of clear to pale cream-colored fluid. The presence of numbers of cystic spaces which may also range upwards to several centimeters in size throughout a fibrotic breast is indicative of a transitional state with one of the other types of chronic cystic mastitis.

The *microscopic* picture in adenofibrosis depends partly upon the duration of the process. Except for the long-standing cases, especially in elderly women, the usual case will demonstrate all the changes of the disease. The early changes consist of a moderate increase and proliferation of the glandular elements. The glands are grouped in lobular fashion, show moderate irregu-

larity of form with bud-like outbranching. The epithelium consists of two or three layers of small, dark, rounded cells. There may be slight dilatation of the ducts, chiefly due to a collection of bright reddish-colored secretory material, also present in the lumina of the glands. In many instances a zone of clear edema will be found about the lobule and likewise between and around the individual glands. Into this edema, fibroblasts and older connective tissue cells will be seen proliferating. In later phases this connective tissue proliferation and behavior becomes more and more prominent, forming the essential manifestation of adenofibrosis. Lobules are set apart by it, later the individual acini are separated from each other until no lobule arrangement can be distinguished. The end-result is one of widely separated glands and ducts lying in a very dense connective tissue stroma. In many such breasts large areas consisting wholly of connective tissue are found. Often, especially in senile women, only traces of atrophic glandular elements remain.

These are the findings of typical adenofibrosis, there should be no evidence of cyst formation or epithelial hyperplasia. When such changes are present as concomitant findings, it indicates that another type of chronic cystic mastitis has become superimposed upon adenofibrosis.

2 *Benign Parenchymatous Hyperplasia*—As indicated by the term selected, this condition consists of a hyperplasia of both the glands and ductal elements of the breast. At the outset one must note that this is an epithelial proliferation, in contrast to adenofibrosis which is essentially an alteration of the breast by connective tissue changes. The manifestations of benign parenchymatous hyperplasia may be explained as the sequelae to an increased proliferation of the glandular elements followed by secretory activity. The secretory products are neither evacuated nor absorbed. They collect in the ducts, dilating them to form cysts. Stagnation and perhaps chemical alterations of this material allow it to act as an irritant upon the lining epithelium of the glands and ducts, thereby inducing a further irritative hyperplasia in their epithelia. This irritation theory, as held by Cheate and Cutler,⁴ Ewing,⁵ and others, is very probably a factor of importance, but is probably a secondary one. The initiating factor for the preliminary glandular hyperplasia is probably a hormonal change, possibly an increase in estrogens.

The most significant *gross findings* in benign parenchymatous hyperplasia are the nodules present upon palpation. The nodularity is due to the presence of cysts, and dilated cord-like ducts. The stromal consistence is only moderately increased, and does not form such a significant feature as in adenofibrosis.

In the early stages *palpation* of the breasts reveals localized or diffuse areas of increased consistence in which are minute shot-like areas. Thin breasts, lacking any appreciable fat pad, may allow one to distinguish a number of swollen cord-like ducts which radiate away from the subareolar region. These ducts may reveal bead-like enlargements along their course. The later phases present a more generalized and distinguishable nodularity. The nodules are usually enlarged, ranging up to two centimeters in size and are thus more readily made out. They have a firm but resilient con-

sistence Their multiplicity and only partial fixation are important features in differentiating them, since fibro-adenomas are usually freely movable, while carcinoma is significantly fixed as well as harder in consistence

The *cut surface* in benign parenchymatous hyperplasia presents variable yet significant numbers of cystic spaces throughout a pale gray or light tan-colored stroma In a strict sense these are not true cysts, but the sectioned

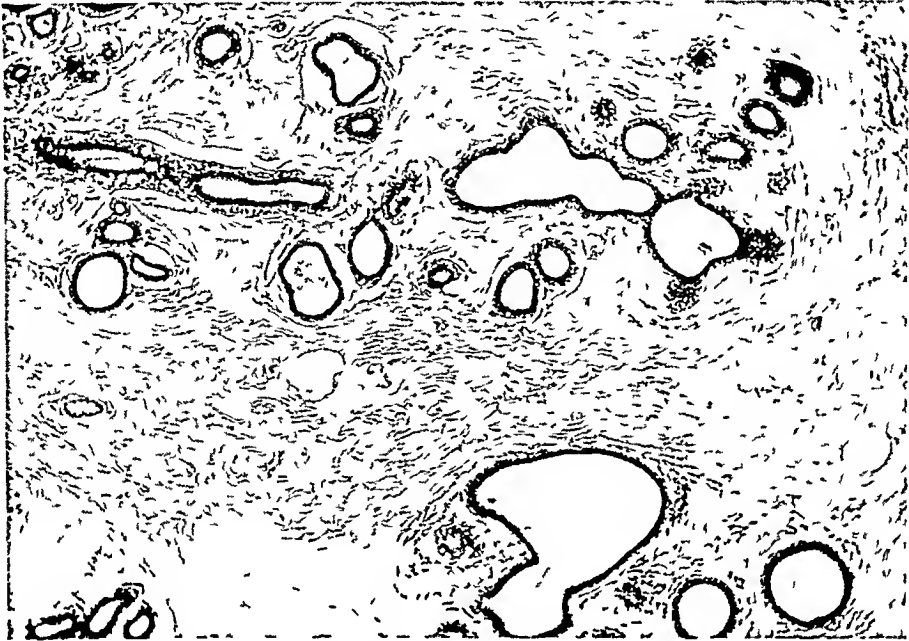


FIG 3—Benign parenchymatous hyperplasia, revealing an increase in number of the ducts with dilatation and an increase in the number of the cells lining some of the ducts The interstitial connective tissue is unusually dense here, but will be moderately increased in almost all cases of chronic cystic mastitis

lumina of dilated ducts They are called cysts due to their general rounded outline, discrete character, and fairly distinct wall When exposed, but before incision, they may appear as silver-blue to red-brown rounded masses These features are due to retained material shining through thin duct walls Incision of the cysts yields inspissated material which may show a wide range of character, from cloudy grayish-tan fluid to deep yellowish-brown material of buttery consistence Removal of this material should reveal a smooth gray-white lining, a significant feature since absence of any epithelial alteration of the cyst lining (such as papillations) denotes the benign character of the lesions

The stroma of parenchymatous hyperplasia is neither as abundant nor as firm in consistence as that of adenofibrosis, in which condition it forms the prominent feature Cystic spaces, which are relatively uncommon and insignificant when present in adenofibrosis, form the basic picture in benign parenchymatous hyperplasia One variation of benign parenchymatous hyperplasia should be noted In some cases, the cut surface of the breast will present numbers of minute gray-pink specks, denoting foci of glandular hyperplasia

Such areas are not a very prominent gross finding, but are, however, commonly found in the microscopic sections. For this reason a specific term *adenosis*, referring to alterations of glands, has been selected to identify such lesions. Microscopic examination may reveal a few areas composed of lobular or diffuse proliferations of glandular elements in contrast to the ductal alterations more commonly found. Since other sections from the same breast will generally show parenchymatous hyperplasia, it was felt that adenosis should be recognized, but relegated to a subgroup of parenchymatous hyperplasia.

The benign character of parenchymatous hyperplasia may be established on the basis of two gross findings. These are (1) the absence of gross papillations of the epithelial linings of the enlarged ducts and cysts after evacuation of their contents, and (2) a uniform, moderate consistence, showing no irregular firm to hard areas. Breasts presenting either of these findings should be considered in an advanced state of epithelial hyperplasia and should be examined carefully by histologic examination for the presence of precancerous or malignant changes.

Microscopically, benign epithelial alterations in the lining epithelium of glands and ducts form the most significant finding. In most instances the changes are most prominent in the ducts, the glands being altered but to a lesser degree. A second prominent feature of benign parenchymatous hyperplasia is the presence of glands and ducts dilated to cystic proportions, and filled with secretory products and epithelial debris. The epithelial changes consist of a moderate increase in the size of the cells, which assume a polyhedral outline. Their cytoplasm is more prominent and the nuclei become darker staining. The cells often appear in several layers, and show a tendency to form pseudopapillary processes with no supporting stroma. The picture is one of overgrowth, but cannot be considered neoplastic in type. The benign character is indicated by the uniform size and shape of the cells, even staining qualities, a regular pattern or stratification of the piled-up cells, and lack of bizarre mitoses. There is no tendency towards invasion of the surrounding stroma.

While the changes described above are usually most prominent in the ducts, there may be a sufficient preponderance of glandular hyperplasia (i.e., increase in number of glands) and alteration as to warrant designation of the subgroup *adenosis*. In this type of lesion, glands, which are increased in number, are arranged in lobular patterns, or as a diffuse proliferation. The glands are composed of darkly-staining epithelial cells, which, likewise, may be several layers deep. There are no other significant changes beyond those described in the ducts, and the hyperplasia is well within benign limits. The glands in adenosis frequently contain a reddish secretory material in their lumina.

Accompanying these epithelial alterations of glands and ducts are the cystic changes. Reddish-staining secretory material is seen in many of the glands and as this collects in the ducts, cysts are formed by dilatation. The dilated cystic ducts are lined by flattened epithelium. In the cyst lumina

the secretory material is often found to contain desquamated cells and their debris

These are the essential findings of benign parenchymatous hyperplasia. The mild degree of epithelial hyperplasia as described is benign in nature. It is important to note that we are dealing with *epithelial changes* and that as such we must remember they may be transformed to or be accompanied by more advanced epithelial changes, which could alter the findings to one of precancerous hyperplasia or actual carcinoma. Again, benign parenchymatous hyperplasia may accompany or become superimposed upon the changes of adenofibrosis.

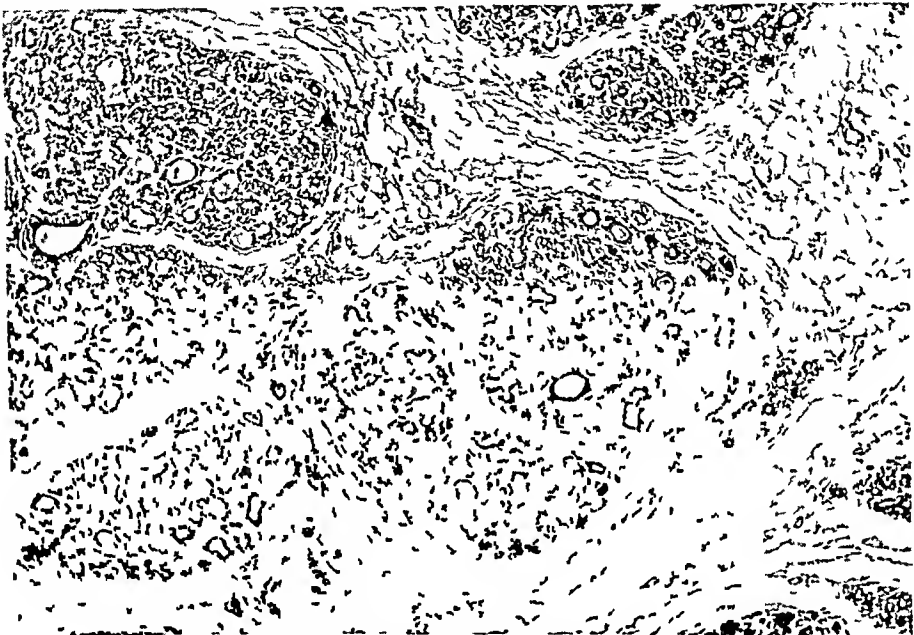


FIG. 4.—Benign parenchymatous hyperplasia, revealing marked increase in glandular elements, presenting a picture which we have designated as adenosis.

3 Precancerous Hyperplasia—By definition, this group consists of those cases having an epithelial hyperplasia which resembles that seen in carcinoma. The hyperplasia exceeds the benign limits characterizing parenchymatous hyperplasia, yet lacks the invasiveness and anaplasia of cancer. This is a controversial group clinically speaking, inasmuch as it is impossible to tell which of these cases will go on to actual malignancy. The authors have seen this lesion in close proximity to unquestioned cancer, and have seen cancer develop in breasts known to harbor such changes through biopsy at some previous time. Also, we have found microscopic fields in these lesions which lacked only the criteria of invasiveness to be called cancer. Such areas cannot be ignored under a simple benign diagnosis—the welfare of the patient and surgical conscience demand a more precise terminology. The existence of lesions bearing a potentiality for malignancy is in the authors' opinion an adequate reason for separating them in a definite group. We wish to describe these lesions pathologically, discuss their pathologic possibilities, and thereby offer a basis upon which therapy may be prescribed.

First, we wish to emphasize the unfortunate fact that *there are no criteria by which this group may be identified or separated from parenchymatous hyperplasia except microscopically*. Neither palpation nor examination of the cut surface yields distinctive diagnostic findings. Conclusions drawn from such examinations should be considered presumptive only, and chiefly for the purpose of selecting areas for thorough histologic study. Nearly all such cases will present features resembling those of benign parenchymatous hyperplasia (which is frequently concomitant), and the gross pathologic problem resolves itself into the selection of areas for microscopic study.

There are a number of *features which will aid in the selection of tissue blocks* to find the most hyperplastic and suspicious areas. These are (1) The lining epithelium of ducts is usually smooth, glistening, and silvery-pink in color. Any discolored, roughened, thickened, or pebbled areas should be regarded with suspicion and removed for section. Sometimes in the larger collecting ducts one may find low papillations, or even discover an intraductal papilloma. These structures should therefore be examined carefully. (2) The cross-sectioned lumina of ducts and cystic spaces will be filled with secretory debris. Upon moderate pressure this material can be evacuated, leaving a fairly smooth inner wall. Spaces which yield only a central core of their contents while a dirty gray-tan debris remains should be regarded with care. (3) Areas which appear to be a coalescence of minute cystic spaces with ill-defined walls and but little excrescent debris are especially suspicious. (4) Here and there areas of a firm indurated character are often palpable, but not readily visualized. These likewise should be examined microscopically, frequently necessitating a number of tissue blocks. The authors have found that search for these areas is greatly facilitated by a definite technic. If after a preliminary examination by palpation and a cut section one is able to rule out cancer, further examination is deferred to fix the entire specimen in formalin. After fixation, the specimen is washed, and then examined by making parallel cut-sections through the entire specimen. These should be about one centimeter apart so that the resultant slices may be palpated from both sides. Much information may be gained by such a method since very small areas of increased firmness will be discovered when palpated from both sides between thumb and forefinger. The value of this technic is apparent when one emphasizes that the entire problem in these lesions is a microscopic one. Since the gross findings are very inconclusive, the microscopic problem can only be solved by an adequate search for the evidence of precancerous hyperplasia by numerous tissue blocks. Naturally most of the areas removed will show benign parenchymatous hyperplasia. *Only one part of the breast, perhaps only a single block, may show a precancerous change.* When a precancerous change is found, it becomes the essential feature in diagnosis, regardless of the benign character of the remaining breast.

Since the microscopic problem is an extremely important one, good microscopic sections as well as pathologic familiarity with these lesions are necessary for an accurate diagnosis. The authors do not believe that a frozen section

reveals the microscopic changes found in these lesions in a manner which will allow an honest interpretation. We have seen a number of errors in the conclusions drawn from frozen sections. It is difficult enough to make an accurate interpretation on excellent sections. Since this problem is so important to the patient's future welfare, we feel that only excellent microscopic sections should be used in identifying these cases.

The *microscopic diagnosis* of precancerous hyperplasia is built upon a combination of findings which indicate advanced epithelial alterations beyond

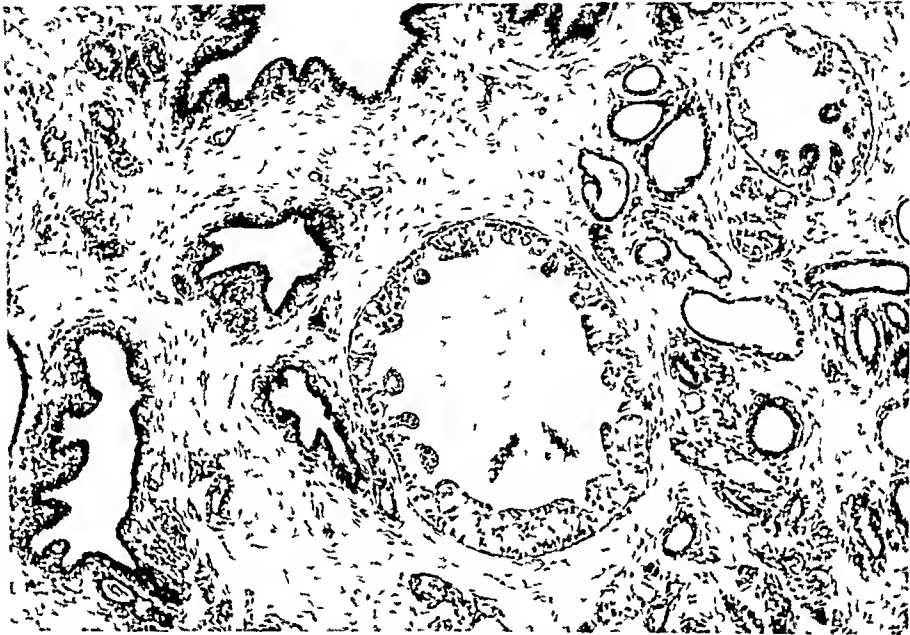


FIG 5—Precancerous hyperplasia, revealing papillations and layering of cells lining the ducts, many of which are dilated

those seen in parenchymatous hyperplasia and approaching the epithelial changes of cancer. Since all cancers of this organ are not alike, neither will the precancerous alterations be similar. Thus one may encounter various types and degrees of epithelial overgrowth.

In most cases there will be a generalized gland and duct hyperplasia as seen in benign parenchymatous hyperplasia. The features manifested in precancerous hyperplasia begin as an increased number of the cells lining ducts and glands, *chiefly the former*. Plication, pseudo or actual papillary processes are found associated with these multilayered epithelia. Gland and duct outlines become distorted and some become filled with the overgrowth of their lining cells. Somewhat more advanced stages may show well defined microscopic cystadenomas and papillary adenomas. Ducts are found plugged with swollen epithelial cells. There are alterations of form and arrangement, size and numbers of glands and ducts, and their cellular components, but of themselves these changes are not necessarily precancerous. If in addition one finds alterations of the cells, consisting of increased and variable size, irregular staining features along with swollen, vacuolar and hyperchromatic

nuclei which display increased mitoses, we are justified in terming the lesion precancerous. Cell polarity is indicated by the pattern of the cells in relation to their underlying wall or the stromal core of a papillary process. When the cells range side by side in an even, regular pattern with their long axes parallel, the lesion is not advanced. Conversely, if there is heterogeneous grouping of cells with no attempt to form a pattern, such as when cell axes are lost or point in all directions, then one is dealing with a more advanced lesion. While the resemblance to cancer is at times remarkable, we do not feel justified in a diagnosis of cancer without the criterion of actual invasion. We believe that these features of cellular overgrowth in its various forms (plication, papillations, and filling of lumina), along with variable polarity and cellular changes approaching anaplasia, are all features which resemble those seen in cancer, but do not constitute cancer without cellular infiltration of the breast stroma. We do feel that hyperplasia of the precancerous type as described should be classified as a separate entity, particularly since treatment is different from that of other types of chronic cystic mastitis.

4 *Cystic Disease (Involution Cysts)*—This condition may be defined as a solitary-appearing cystic mass of the breast, usually found in elderly women. The appearance of the cysts during the menopause or immediately following has led to the conclusion that their origin is in some manner sequel to the involutionary changes of the breast, and the concomitant endocrine alterations of this period. There is no evidence of any neoplastic or inflammatory relationships. There are no epithelial changes which would point to any relationship to cancer, hence they are essentially benign in nature. Frequently they arise on the anterior surface or lateral margins of the breast, in which position part of the cyst may be raised above the breast surface, the remainder being implanted in the breast parenchyma.

Gross pathologic examination of the excised specimen reveals a discrete, rounded, fairly movable mass which is palpably tense, but not definitely hard. The mass, containing fluid under pressure, will not fluctuate, but yields elastically in some instances. They are usually more resilient than the average fibro-adenoma. Usually a single cyst, ranging from three to six centimeters in size, is found, although several smaller satellite cysts may be grouped around the base of a larger dominant cyst, on other occasions small cysts may be matted together and to palpation give the impression of a single mass. Upon exposure, some of the cysts will present the typical "blue dome" of Bloodgood. All will not present such an appearance, since some are thick walled or deeply embedded in the breast substance. Incision into the cyst allows a serous or semicloudy fluid to escape, usually spurting from pressure. Cysts containing serous fluid will generally show a smooth silvery-white interior lining, whereas those having cloudy fluid present a dull, light gray lining which resembles granulation tissue. The smooth, unaltered lining of the cysts characterize the condition as benign. No papillary processes or other epithelial changes of the lining are present, therefore little relation to cancer exists. The cyst "walls" are composed of gray-white tissue, actually the sur-

rounding breast parenchyma which has been compressed by the expansion of the cyst. They have a leathery consistence which cuts with considerable resistance. The thin walls of the 'blue dome' variety allow their contents to shine through, thus yielding the characteristic appearance. They are found often near the surface, the small amount of overlying parenchyma being thinned and compressed as the cyst expands upward. The remaining breast may show any of the other varieties of chronic cystic mastitis which could be present before cystic disease developed. However, most cases show only the soft fibro-fatty tissue of the involuted breast.

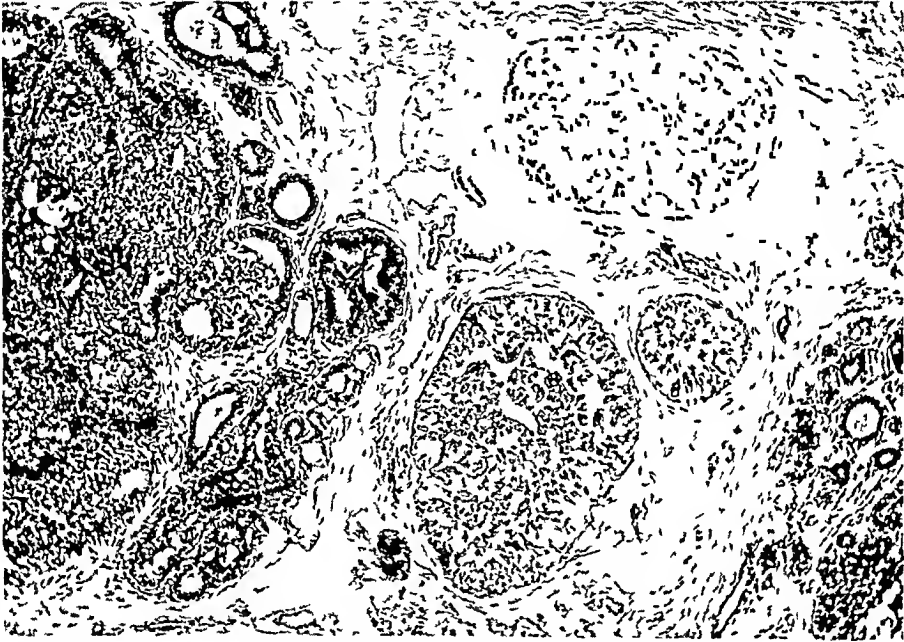


FIG. 6—More advanced stage of precancerous hyperplasia, revealing a growth of lining cells sufficient to fill the ducts. However, there is still no invasion suggestive of malignancy, although the cells of the ducts as well as glands are irregular in size and shape and stain deeply. Mitoses are common.

Microscopically, the cyst wall is found to have a rather fibrous stroma containing flattened and compressed parenchyma, the lining epithelium is usually shrunk and pale, and atrophic in appearance. The serous type of cyst is found to have a single layer of flattened cells forming its lining. The cysts having a cloudy fluid content show a few layers of similar small cuboidal type cells which are loosely held together and appear desquamative. These are sometimes infiltrated with a few lymphocytes. Degeneration and desquamation of these cells would account for the cloudy fluid in the cysts. These minimal epithelial alterations signify the benign nature of the cystic structures termed cystic disease.

RELATIONSHIP OF CHRONIC CYSTIC MASTITIS TO CARCINOMA

Years ago there was by no means complete agreement that chronic cystic mastitis would develop malignant characteristics. However, practically all of the investigators reporting on the disease during the past few years have concluded that carcinoma may and does arise in chronic cystic mastitis.

One of the most convincing of these studies is that reported recently by Warren⁶ He studied the incidence of cancer of the breast in the State of Massachusetts as compared with another series from Toronto After this study he concluded that "the breast cancer attack rate for women with chronic cystic mastitis and related lesions in the age-group from 30 to 49 years is 117 times the rate for the Massachusetts female population, in the group over 50 years of age, 25 times as great, in another group, 45 times as great" Cheatle and Cutler¹ have estimated that at least 20 per cent of their cases of cancer arose in areas of chronic cystic mastitis The authors are likewise convinced that carcinoma of the breast frequently arises in areas of chronic cystic mastitis Since we have observed carcinoma develop in areas of precancerous hyperplasia, and have encountered this type of lesion in 15 or 20 per cent of our cases of carcinoma of the breast, we are convinced that there is a definite relationship between carcinoma and chronic cystic mastitis, particularly the type which we have described as precancerous hyperplasia As previously discussed, it is impossible to estimate, with any degree of accuracy, what percentage of cases of chronic cystic mastitis might develop carcinoma, since suspicious lesions of the persistent type are removed surgically

CLINICAL MANIFESTATIONS

There are relatively few manifestations of chronic cystic mastitis Differentiation of the various types cannot be made on symptoms alone because of the extreme variability of complaints As discussed below, examination will help to a great extent Pain is the most constant complaint, but it is extremely variable in intensity It is by no means present in all cases It is usually increased during menstruation, and rarely severe In patients complaining of severe pain, findings are apt to be minimal, in fact such cases are usually best classified as mastodynia, which is probably not related to chronic cystic mastitis In these cases, examination is usually negative

In about 5 per cent of cases discharge from the nipple will be noted In about half of these (Hinchev⁷) the discharge will be bloody

Examination usually reveals a slight enlargement of the affected breast The breast tissue itself is not attached to the skin Tenderness is fairly constant, and is usually more pronounced over the nodules, but the location may change from day to day

In *adenofibrosis* the whole breast is apt to be involved in the disease process The parenchyma is indurated rather diffusely and has an elastic resiliency The surface of this disk-shaped breast tissue is roughened but not very nodular In this group tenderness as well as pain is usually mild

In *benign parenchymatous hyperplasia* the indurated areas are apt to be local and possess nodular characteristics These nodules vary from 0.5 to two centimeters in diameter and are usually cysts containing fluid under a variable amount of pressure The stroma itself is less firm than in adenofibrosis Tenderness and pain are variable, on some occasions being quite prominent

In *precancerous hyperplasia* the history and examination will be very similar indeed to parenchymatous hyperplasia. Only on cut section of the excised tissue can an impression be gained as to the seriousness of the lesion. Even then impressions are usually inaccurate until the microscopic section can be seen.

In *cystic disease* the breast itself is usually atrophic, particularly since most of these patients are in the older age group, past the menopause. Large nodules up to four or five centimeters in diameter may be palpable.



FIG 7.—Cystic disease, revealing cystic spaces (dilated ducts?) with no cellular hyperplasia and a relatively slight increase in connective tissue elements.

These nodules, which are of course cysts, may be palpated as resilient non-fluctuant areas. Many of the cysts are of the type described by Bloodgood as "blue dome" cysts. Frequently numerous small cysts are present and so matted together that the involved area is palpated as a solitary nodular mass, only on cut section may the true nature of the lesion be revealed.

Differential diagnosis may be extremely difficult. The lesion may simulate benign neoplasms, but fibro-adenomas are usually more circumscribed, and firmer in consistence. Likewise, there may be extreme difficulty in differentiating chronic cystic mastitis from early cancer. Although a diffuse nodularity implies the presence of chronic cystic mastitis, yet there is always a danger that a carcinoma may be developing in one of the nodules, unless the patient is quite young. One of the most reliable signs in aiding differentiation of chronic cystic mastitis from carcinoma is skin retraction, which is fairly constant in carcinoma, even of the early type. Rarely, indeed, is skin retraction present in chronic cystic mastitis, unless an acute inflammation has been present at some previous time. This difficulty of differentiation complicates treatment as will be discussed below, and frequently influences the physician toward operative therapy.

CHRONIC CYSTIC MASTITIS

TREATMENT

A decision first must be made as to whether or not nonoperative or operative treatment is indicated. In general, conservative treatment in young women is safe and more strongly indicated than in women past the age of 45 because of the possibility of cancer in the latter group. In young women a nodular breast having no skin attachments or other characteristics of carcinoma can be treated safely, by the conservative methods, at least for a time. This treatment is particularly indicated when the lesion has been present only for a short time, because on many occasions the lesion will disappear spontaneously. As an example, we might briefly present the clinical picture and progress in a young woman 26 years of age, who had

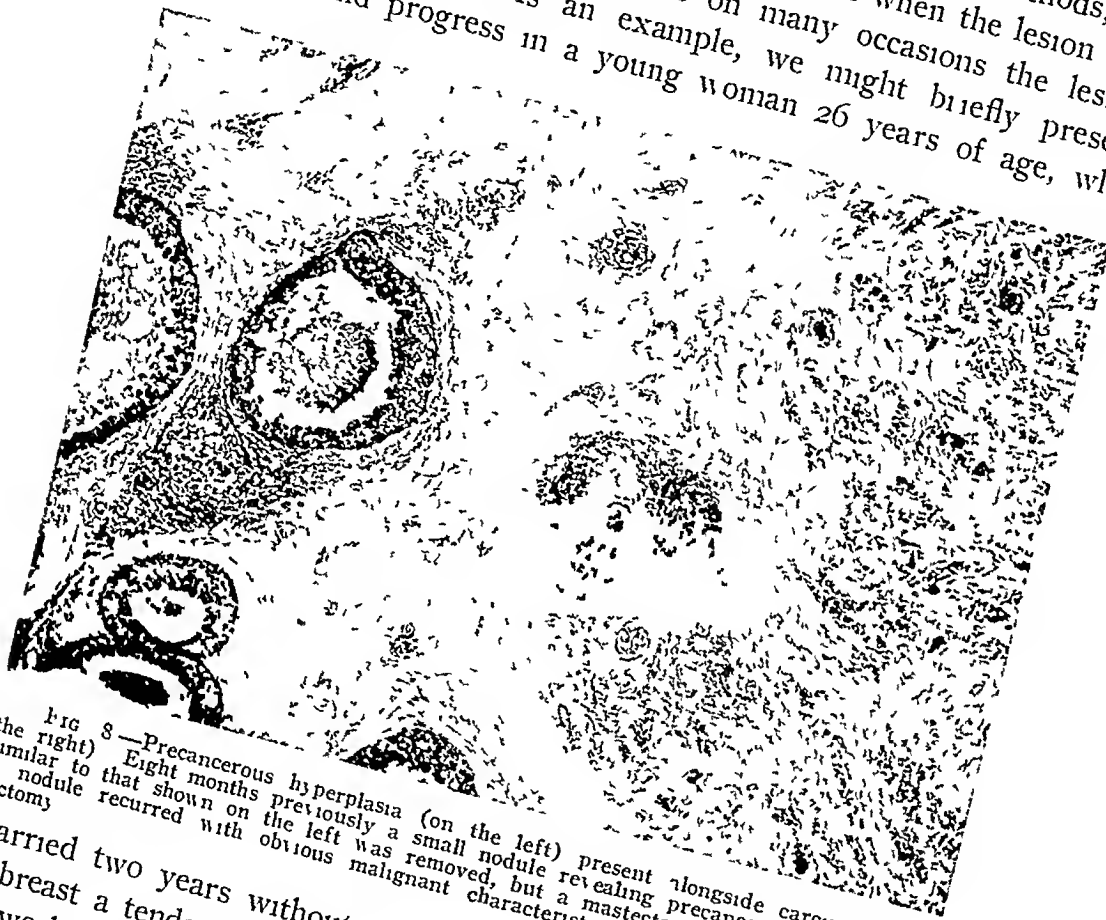


Fig 8—Precancerous hyperplasia (on the left) present alongside carcinoma (on the right). Eight months previously a small nodule revealing precancerous hyperplasia similar to that shown on the left was removed, but a mastectomy was not performed. A nodule recurred with obvious malignant characteristics, necessitating radical mastectomy.

been married two years without pregnancy. When first seen, she had in her left breast a tender mass, two centimeters in diameter, which was only of four weeks' duration. This nodular mass had the characteristics of chronic cystic mastitis, but under observation disappeared spontaneously within three months.

Adequate support of the breast is indicated for the relief of pain. Heat therapy may be helpful. It is well known that pregnancy and lactation cause chronic cystic mastitis to regress.

All sorts of hormone therapy have been advised and used in chronic cystic mastitis. However, the authors have had the same experience as Taylor,⁸ who reports that he has not seen any favorable effects from hormone therapy.

As intimated previously, the clinician may be unwilling to delay operative treatment in a patient in the cancer age with chronic cystic mastitis over

an indefinite period, particularly if one of the nodules is more indurated and less defined than the others. In women past 40 or 45 there is a tendency to resort to local excision, particularly if the mass has been there more than a few months. Attempt should be made to remove all of the nodules. This may require resection of half the breast. Regardless of the amount of breast involved, considerable normal tissue adjacent to the nodules must be removed so that all the diseased area is included in the resected tissue. If a wedge-shaped sector is removed, the cut edges can be approximated, thereby eliminating dead space. It is essential to eliminate dead space, since infection is apt to develop in these areas. Hemostasis must be carefully achieved, spontaneous cessation of bleeding occurs slowly on the cut surface of breast tissue, because the firm breast tissue does not allow retraction and contraction of the cut vessel. A drain may be inserted for 12 or 24 hours, but should not be allowed to remain longer than that time. Under ordinary circumstances the wound is closed without drainage.

As stated previously, it may be impossible to identify precancerous areas by clinical means in the mastitis lesions. We are firmly convinced that if the microscopic section reveals precancerous tissue, as illustrated in Figure 5, or 6, a complete mastectomy (not radical) should be performed. We have observed carcinoma develop in a breast following inadequate removal of precancerous tissue. Moreover, it is now estimated by most authorities, including Cheate and Cutler,⁴ and others, that at least 20 per cent of the carcinomas of the breast develop in, or pass through, a stage of chronic cystic mastitis. Ewing⁵ has stated that "about 50 per cent of the breasts excised for cystic disease show pronounced precancerous changes or miniature carcinomas." We are therefore, firmly convinced that when local excision reveals hyperplasia of the precancerous type, the entire breast should be removed.

SUMMARY

In view of the marked confusion as to the classification of the various types of chronic cystic mastitis, we have attempted to separate the lesions into groups which would have a pathologic as well as clinical significance. From this standpoint, it appears to us that chronic cystic mastitis can be divided into four groups as follows: (1) Adenofibrosis, (2) benign parenchymatous hyperplasia, (3) precancerous hyperplasia, and (4) cystic disease. At times a single specimen may reveal gradations of all four types described, but with few exceptions, one of them predominates. A lesion is classified as precancerous even if only a very small portion of the breast reveals this type of change. The types of pathologic changes herein described have been recognized and described previously, but we have endeavored to formulate a classification which would avoid complicated terms and yet have a pathologic as well as clinical significance.

Our classification is based somewhat upon the supposition that carcinoma may at times be superimposed on chronic cystic mastitis. We are convinced as are practically all workers publishing material on the subject during the past few years, that carcinoma can and does develop in certain types of

CHRONIC CYSTIC MASTITIS

chronic cystic mastitis In our estimation and experience, carcinoma is most apt to develop in precancerous hyperplasia, which is in itself a benign disease In view of the strong possibility of development of carcinoma in precancerous hyperplasia, we recommend simple mastectomy (not radical) if removal of a nodule reveals a hyperplasia of the precancerous type Adenofibrosis and cystic disease are least susceptible to malignant change, and fortunately are readily distinguishable clinically and pathologically (particularly from the pathologic standpoint) from parenchymatous hyperplasia and precancerous hyperplasia

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DISCUSSION DR J GARIAND SIERRILL Louisville, Ky The report of Doctor Cole is excellent and I appreciate it very much Many of the best surgeons think it wise to obtain a biopsy in doubtful cases, however, in my opinion there is the possibility that one may be misled if the section is taken from a portion of the growth in which malignant change is not yet present, whereas in another part the evidence would be clear-cut Then, too, there is the possibility of spreading the disease if the proliferating cells are transported as a result of the section

We have usually attempted to make a diagnosis from the clinical history and physical examination On this account "when in doubt it is well to play trumps" One rarely makes an error if the symptoms point strongly to cancer, and we have had no regret because of early and radical removal of a suspicious neoplasm When in doubt it is wise to remove it at once, radically, and if considered wise, to follow this by irradiation Two cases have impressed me as to the greater activity of cancer in young women The first was in an unmarried woman age 24, who consulted her physician four days after she first noticed a rounded growth in her breast, with no palpable nodes in the axilla or other evidence of a lesion elsewhere She came to radical removal with complete dissection of the axilla, also had irradiation, yet died within the year In another case, a woman in the early 30's presented a suspicious erosion on the cervix with irregular bleeding The extent was so slight that some doubt of cancer was expressed A most radical removal was promptly performed but without avail

For this reason I am certainly very radical in treatment in young patients On the other hand I have seen an old man live for many years with a skin epithelioma with but little treatment, and finally die of an intercurrent affection, with little disturbance from the malignant growth In my experience growths out from the body are less dangerous than those which tend to extend into the tissues

DR J SHELTON HORSLEY, Richmond, Va Doctor Cole has given one of the best expositions of chronic cystic mastitis that I have heard I should like to ask him if he has observed any connection between the administration of estrin products and the occurrence of chronic cystic mastitis or cancer

DR JOHN C HENTHORNE, Vicksburg, Miss I agree with Doctor Cole that there seems to be a recent increase in the belief that certain forms of cystic mastitis are premalignant. On the other hand, this belief may prove to be more a matter of religion than science and may be a step in the wrong direction. The pioneer work on cystic mastitis as a benign disease not related to cancer was done by Bloodgood,* who found that the incidence of cancer was somewhat less in patients who had chronic cystic mastitis than it was in the general population. Campbell,† whose work was called to my attention by Doctor Bell at the University of Minnesota, came to the same conclusions as Bloodgood.

One of the slides shown by Doctor Cole demonstrated the peculiar type of eosinophilic epithelial hyperplasia sometimes called Schimmelbusch's hyperplasia. For many pathologists this type of hyperplasia is a landmark of benignancy in questionable lesions of the breast. In another slide, the last, there was demonstrated a comedocarcinoma. In this type of carcinoma the cystic cavities are not related to cystic mastitis, but are caused by necrosis of the cancer epithelium in the centers of cell masses and, therefore, this slide in my opinion does not demonstrate any relationship between cystic mastitis and cancer.

Doctor Ewing once pointed out that occasionally pathologists become interested in certain forms of cellular hyperplasia and want to call them malignant because of bizarre morphology. Ewing suggested that in order to establish the malignancy of hyperplasias of this type it was necessary to follow a number of patients who had this type of disease long enough to demonstrate that some of them develop metastasis or other well known phenomena characteristic of malignant tumors.

It seems to me that religious adherence to schools of thought based upon the morphology of chronic cystic mastitis may lead us in the wrong direction. If clinical observations as suggested by Ewing are carried out, it seems likely that many of the types of cystic mastitis now thought to be precancerous will prove to be completely benign if the patients are followed as closely as Bloodgood followed his cases, some for a period of 25 years.

DR WARREN H COLE, Chicago, Ill (closing) Doctor Sherrill is correct in his statement that if you cannot be sure about the diagnosis, and fear cancer, the breast should be removed or a very wide excision done. But the chief point in my presentation is to urge improvement in our diagnostic ability so that we will not have to remove every nodular breast we see. One can readily see how many mastectomies would be performed if we adopted the policy of removing all nodulous breasts, since perhaps the majority of women past the age of 40 have a variable amount of nodularity in their breasts.

Doctor Horsley's question is hard to answer. We had one patient develop carcinoma while under theelin therapy, but perhaps that patient would have developed carcinoma anyway. The experiments of Loeb and Lacassagne prove that in mice, carcinoma can be produced with estrin, but they used large doses. Anyway, if I were a woman I would not want to take estrin compounds over a long period of time. I am sufficiently fearful of the danger of production of carcinoma by estrin compounds that I do not believe we should prescribe them except for temporary use.

Doctor Henthorne called attention to the fact that Doctor Bloodgood did not believe carcinoma developed in chronic cystic mastitis. I might also add that Doctor Bloodgood, like anyone else, may at times have been in error. I believe I am quoting Geschickter (who was an associate of Bloodgood) correctly, when I say that he (Geschickter) now believes that carcinoma does develop in chronic cystic mastitis. The best clinical follow up report I know of on this subject is that of Shields-Warren, who has conducted extensive research into the possibilities of development of carcinoma in chronic cystic mastitis; he is convinced from his studies that these patients do develop carcinoma. The area of the section which Doctor Henthorne thought revealed comedo carcinoma, true enough resembles that lesion, but in reality shows degenerated epithelial debris in ducts which are the seat of advanced epithelial hyperplasia. If we did radical mastectomy for such lesions we would frequently be guilty of performing needless radical surgery for benign lesions.

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THE SURGICAL MANAGEMENT OF CRYPTORCHIDISM*

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THE FACT that some confusion still exists in regard to the management of the undescended testicle and the rather unsatisfactory end-results we have noted in some of the 110 cryptorchids that have come under our care has encouraged presentation of this subject. Our purpose will be to indicate that results generally could be improved by a more widespread adjustment of management to conform with certain significant and apparently unappreciated observations.

For several years attention has been focused on the response of the undescended testicle to endocrine stimulation. Rational evaluation of this form of therapy seems to have been delayed an unusual time in some quarters. That the method has a natural appeal is easy to understand. Its limitations and dangers have not, however, been fully realized. While time does not permit a comprehensive discussion of hormonal treatment and in spite of the fact that only a few definitely proven undesirable effects have been reported, our own observations, and those of many others, have convinced us that artificial stimulation of the retained testis by any gonadotropic or androgenic substance has a small field of usefulness—is practically unnecessary and may be harmful. We must remember that the intimate relationship of the testicle with the thyroid, pituitary, and adrenal is as yet poorly understood, and it is our belief that stimulation of the endocrine system has harmful potentialities and should be avoided, in that it may result in glandular imbalance or other systemic disturbances.

For purposes of discussion it is desirable to classify cryptorchids into three groups, *viz*: Group I. Endocrinopaths with retained testes. Group II. Those with ectopic testes. Group III. Those with inguinal canal or abdominal retention. Pseudocryptorchids and infants with spastic retraction require only recognition as such and no consideration from a treatment standpoint.

GROUP I—ENDOCRINOPATHS WITH UNILATERAL OR BILATERAL NONDESCENT

These boys must be carefully studied from an endocrine standpoint. Most of them present the familiar adiposogenital syndrome of Frolich, with hypogonadism. For these, hormonal therapy is appropriate and frequently results in testicular descent. We must, however, remember that physiologic variation in pituitary function occurs, and may result in obese changes with questionable genital hypoplasia and with delayed descent of the testicle. We have seen adequate genital development proceed and descent occur in untreated boys of this type. It is highly probable that endocrinal treatment

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La.

has been given undeserved credit for producing descent in many of such instances, especially if injections were begun shortly before or at the time of puberty. Boys in this group, whose testes fail to descend at puberty or who have testicular ectopy, will, of course, require surgical attention. As a whole, the group is a small one. In our series less than 3 per cent

GROUP II—THOSE WITH ECTOPIC TESTES

This group is also small. The testicle is outside the path of normal embryologic descent. Surgical attention is necessary and may be instituted at any age, *i e*, whenever one is satisfied the testis is ectopic. Certainly one could not expect spontaneous descent to occur in any of this group. The futility of hormonal treatment is apparent. Indeed, there is considerable experimental evidence in support of definitely harmful results from its use. Mimpriess reports degenerative changes in the mechanically retained testes of rats treated by hormonal injections. Eisenstadt, Appel, and Frankel noted similar degenerative changes in the retained testicle of rats subjected to hormonal treatment and at the same time observed no influence on the normally placed gonad. It would seem, then, that for the ectopic testicle, hormonal injections are contraindicated and suitable surgical treatment should be undertaken at any convenient age.

GROUP III—THOSE WITH INGUINAL CANAL OR ABDOMINAL RETENTION

Approximately 90 per cent of cryptorchids fall into this group. The testis is found somewhere along the course of the inguinal canal or occupies a retroperitoneal abdominal position. We, and others, have observed natural spontaneous descent in some boys in this group and usually at the time of puberty when the testicle receives its normal endocrine stimulation. In view of this possibility, postponement of surgery until the advent of puberty or shortly thereafter seems not only rational but advisable, since in this way many surgical procedures will be made unnecessary. Wangenstein has shown that little growth occurs in the testis from birth to adolescence and he also noted little or no difference in the cellular structure of the retained and the normally placed testicle during that time. The significance of these observations deserves emphasis. It would seem then that because of the possibility of spontaneous descent in this group and in view of the fact that the testicle will not suffer degenerative changes by virtue of its undescended position and, further, because surgical accidental destruction will be minimized through fewer operations, observation until puberty or shortly thereafter should definitely improve our ultimate end-results.

The difficulties encountered during the surgical management of the undescended testicle are quite familiar to every surgeon. While normal size and position are highly desirable, this combination is all too often unattainable because of the maldeveloped or atrophic structure uncovered at the time of surgery. We have been impressed with the frequency of separation of the epididymis from the body of the testicle and other developmental defects of equal significance. In one of our patients age 19 a cystic epididymis with

vas deferens attached was in the scrotum while the testicle and vascular cord components were just outside the internal abdominal ring. This caused considerable diagnostic commotion because the cystic epididymis was of good size and felt like a testicle both to examiners and patient. Since the vas deferens joined the scrotal mass, his referring physician was certain the patient had three testes. In spite of anomalies, one must attempt low scrotal placement in all but the hopelessly atrophied in the interest of appearance, internal secretion and morale.

Of the numerous surgical methods devised and employed we are at present convinced that the Keetley-Torek procedure is best adapted. This technic is so well known that I shall not recite its description. Two or three points, however, merit attention. Scrotal-thigh anastomosis materially aids development of the scrotum, and prolonged thigh fixation of the testicle, by overcoming contractility in the elastic structures of the cord, prevents subsequent retraction to the top of the scrotum, where we have so often found it after other surgical methods.

Satisfactory cord lengthening is of course essential. Deliberate and painstaking care during this procedure cannot be overemphasized. In this connection we have found it quite helpful to liberate the vas deferens and cord vessels separately well inside the internal abdominal ring, and frequently follow them more than a finger's length in their retroperitoneal position. One is surprised at the amount of elongation obtainable in this way and very grateful in that intrafunicular dissection is minimized. The spermatic artery is often extremely small, difficult to recognize and easily injured. We seriously doubt that the testicle can be adequately nourished by the artery to the vas and believe that in most instances atrophy of the testis or failure to grow after orchiopexy is the direct result of imperfect surgical technic in cord handling. To avoid it one must exercise the greatest care during this procedure and be certain that fixation of the testicle to the fascia of the thigh is accomplished without undue tension.

From the standpoint of end-results insofar as low scrotal position is concerned our experience with the Keetley-Torek method has been highly satisfactory. If, at the time of surgery, the testicle can be brought to a sufficiently low level one may be assured it will retain that position when, after thigh fixation, it is replaced in the scrotum. In none of our patients has subsequent retraction to a high scrotal position occurred. On the other hand, in approximately 20 per cent the testis has remained smaller than its fellow. In about one-half of this number its original structure was maldeveloped, while in the remainder the circulation was probably injured at operation. We have employed vitahum prosthesis in two young men in whom unilateral postoperative degeneration occurred. In both of these instances the cosmetic result was satisfactory and we have been unable to detect any unfavorable local tissue reaction.

While the weight of evidence seems to favor a greater incidence of malignancy in the undescended testicle, we have not observed its occurrence

in any of our group, and feel that the possibility of development of malignancy should not encourage removal of the undescended testis, but does condemn intra-abdominal replacement. Orchidectomy should be reserved for testes presenting definite or suspicious malignant changes. Those with extreme degrees of atrophy may also be sacrificed to advantage.

The incidence of hernia varies in reported series from 75 to 90 per cent. We have found a hernial sac in all patients coming to operation, and have employed the Ferguson type of repair in order to avoid any loss in cord length. While the processus vaginalis in many instances is empty, one is usually able to demonstrate a small communication with the peritoneal cavity.

Many investigations have convincingly shown that normal testicular function depends upon low scrotal position. Moore states that "Not only is the congenitally retained testis in a degenerate condition but also an active mature testicle surgically removed from the scrotum with nerves, blood vessels, and vas deferens intact and placed in the abdomen shows marked degenerative changes within the period of a week. It shrinks progressively as the germinal epithelium becomes more degenerate and does not again produce sperm cells as long as confined in the abdomen. If prior to the loss of all residual germ cells the testis is replaced in the scrotum, recovery follows quickly and sperm cells reappear within approximately 60 days." The effect of orchiopexy upon fertility has not been adequately studied from a clinical standpoint. Few authentic records are available. Although McCollum revealed fertility in 82 per cent of bilateral cryptorchids after orchiopexy in contrast to the fertility of 10 per cent in those not operated upon, this would seem to far exceed even optimistic expectations for all cryptorchids.

CONCLUSIONS

It would seem that management of the cryptorchid could be improved by

First—Careful examination of these boys with classification into groups as indicated.

Second—Because of the possibility of natural descent, observation until puberty or shortly thereafter is desirable for those in Group III.

Third—Except for boys with definite endocrinopathy, gonadotropic or androgenic treatment is unnecessary, and may, if injudiciously used, actually be harmful.

Fourth—From the standpoint of ultimate structure and position the Keetley-Torek procedure, or one of its modifications, seems best adapted surgically, and has given better results in our hands.

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EXTRASKELETAL OSTEOGENIC SARCOMA*

REPORT OF A CASE OF OSTEOGENIC SARCOMA OF THE LIP

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AREAS of calcification and ossification, and even of true bone formation, are not uncommon findings in certain inflammatory and neoplastic conditions, particularly in lesions capable of exciting localized hematomas or areas of necrosis. Calcifications and ossifications of this kind have also occasionally been observed in fibrosarcomas arising in soft tissues. In none of the latter instances, however, do the bone elements seem to be formed by the cells of the neoplasm.

In contrast to these relatively frequent observations, the neoplastic cells of a certain rare group of fibrosarcomas of the soft tissues apparently exhibit a perverted tendency to form bone. The perversion is accompanied by other manifestations of osteogenic sarcoma, including the presence of large numbers of foreign body giant cells of the osteoclastic type. Tumors in which this bone-forming process occurs are classified as extraskeletal osteogenic sarcomas.

In 1941, Wilson¹ was able to collect from the literature 30 cases of "bone-forming malignant tumors in the soft parts," to which he added ten other cases of "extraskeletal ossifying tumors," six from the Registry of Bone Sarcoma of the American College of Surgeons and the remainder from the Departments of Surgery and Pathology of the University of Chicago. Three of the ten new cases represented benign growths, and Wilson mentions other nonmalignant cases of extraskeletal ossifying tumors not included in the 30 cases of sarcoma which he collected from the literature.

Wilson points out that myositis ossificans offers problems of differential diagnosis, and it seems reasonable to assume that a case or two of this condition may possibly be included in the 30 cases he collected from the literature, because of the notorious tendency of myositis ossificans to simulate sarcoma histologically. Definite statements cannot be made on this point, since no attempt has been made to review the original material, but it might be said that such an error could occur only in a patient who was cured by local excision of his tumor. In most of the reports, because either recurrence or metastasis was demonstrable, the malignancy of the lesion seems beyond question.

Of the 30 extraskeletal malignant tumors collected from the literature by Wilson, seven, or nearly 25 per cent, were osteogenic sarcomas of the thyroid gland, and 12 or 40 per cent, were osteogenic sarcomas of the breast. Four tumors occurred in the thigh and one each in the gallbladder, the chest wall,

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the abdominal wall, the kidney, the mesentery, the vastus externus, and the gastrocnemius muscle. In Wilson's personal collection, two malignant tumors occurred in the thigh, two in the gluteal region, and one each in the arm, the leg and the mediastinum. The three benign extraskeletal ossifying tumors occurred, respectively, in the forearm, the retroperitoneal tissue, and the thigh.

The seven reported osteogenic sarcomas of the thyroid gland include the tumor reported by Bolders and Pemberton² which represented the single case of this kind observed at the Mayo Clinic in the course of pathologic examination of approximately 40,000 thyroid glands. An additional case of osteogenic sarcoma of the thyroid, not included in Wilson's series, was reported by Batts,³ in 1940.

The twelve reported osteogenic sarcomas of the breast include three so-called "carcinosarcomas," a rare and possibly a distinctive type of tumor. The comment of Saphin and Vass,⁴ that this term is used too loosely and that many cases reported in this category are simply pleomorphic carcinomas, is probably justified. On the other hand, we are ourselves convinced that a distinctive tumor of the mammary gland, containing both malignant epithelial elements and malignant connective tissue elements, really exists. We have in our collection of pathologic specimens a tumor of the mammary gland similar to the three carcinosarcomas in Wilson's series, it contains both malignant epithelial and malignant connective tissue. We are not reporting it at this time, partly because the clinical data in the case are inadequate and partly because we are unconvinced that it really belongs in the group of extraskeletal osteosarcomas, even though the causes for the formation of bone in extraskeletal sarcomas and carcinosarcomas are probably related.

If all reported sarcomas of the mammary gland containing osteoid elements were included in the category of extraskeletal osteogenic sarcomas, the series would be even larger and the preponderance of these tumors in the breast even higher than it is in Wilson's collected cases. The fibrous tissue of the mammary gland is apparently suitably disposed to the formation of bone, and, as Ewing⁵ has pointed out, giant cells of the myeloid type occur in spindle cell and round cell sarcomas of the breast. The first cases of ossified tumors of the breast were reported by Boneti in 1700, and by Morgagni, in 1769. In 1937, as Binkley and Stewart⁶ noted, one author was able to collect 75 such cases from the literature. The collection is probably incomplete, partly because of the frequent difficulty of determining from the listed titles exactly what sort of case is being reported, and partly because many cases are undoubtedly not reported at all. Thus, Wellbrock⁷ reported a mammary sarcoma of this general type in 1929, and, in 1933 demonstrated another similar tumor containing bone to one of us (J. C. H.), but to our knowledge has not yet reported it.

In addition to their possible origin in the tissues of the thyroid and the breast, it seems probable that some osteogenic sarcomas of the soft tissues may develop from old calcified hematomas or from foci of myositis ossificans. One case in Wilson's collected series could readily fit into this group and in

three of the additional cases which he reported the patients had observed hard tumors, in one instance preceded by trauma, for 10 to 12 years before evidences of malignancy became manifest

Turner and Craig,⁸ who reported a personally observed case of osteogenic sarcoma of meningeal origin, studied calcification and ossification in meningeal tumors, and compiled a full list of references to the literature. They also discussed the possible reasons for the metaplasia of fibrous tissue. In the same connection, Wilson pointed out that extraskeletal osteogenic sarcomas have occasionally been produced experimentally by the injection of carcinogenic agents into fibrous tissues of rats.

There are two principal schools of thought concerning the development of osteogenic sarcoma in soft tissues. Broders⁹ takes the position that after anaplasia of fibrous tissue cells has resulted in the development of sarcoma, the neoplastic fibroblasts go through a process of differentiation into osteoblasts, which are responsible for the formation of bone. Mallory,¹⁰ like Leriche and Policard, regards osteosarcomas as fibrosarcomas passively ossified by the conditions of their environment. Whether an actual controversy exists between these two schools of thought is not entirely clear. Apparently, as Batts points out, the proponents of one theory imply that the osteoblasts of the tumor secrete a true osseous substance, while the proponents of the other theory believe that the osseous transformation of connective tissue is an interstitial and humoral process and is, therefore, a phenomenon independent of all cellular action. It is not known whether the differentiation of neoplastic fibrocytes into osteoblasts depends upon the inherent potentiality of the cells or upon their environment, although Broders has clearly demonstrated that from a morphologic point of view such a differentiation actually occurs in tumors of this type.

The case of extraskeletal osteogenic sarcoma of the lip which we are recording herewith is apparently the only one observed to date in which the growth occurred in this particular location. We have nothing to contribute to the theoretic considerations of the subject, except to confirm Broders' morphologic concept, and, therefore, prefer to avoid any controversy concerning the origin of this type of bone tumor.

Case Report—D. H. G., white, male, age 53, was first seen at the Vicksburg Clinic May 29, 1935. His chief complaint was a small sore on the right side of the lower lip, which had been accidentally discovered two weeks before. His family physician had incised the lesion, but no improvement had followed.

The patient smoked an average of ten cigarettes daily but had never smoked a pipe. His previous history was without incident except for three operations—appendicectomy for acute appendicitis in 1903, hemorrhoidectomy in 1930, and left nephrectomy for ruptured kidney in 1931. An uncle and a first cousin had died of cancer.

General examination revealed nothing of note except several carious teeth and advanced pyorrhea; oral hygiene was poor. Local examination revealed a circular, indurated ulcer, 2 cm. in its greatest diameter, along the vermilion border of the right lower lip, midway between the midline and the angle of the mouth. The edges of the ulcer were brawny and were sharply outlined. The lymph nodes of the right submental space were palpable but those on the left were not felt.

Routine uranalysis revealed no abnormalities, and examination of the blood showed values within the normal range. Roentgenologic examination of the chest was also negative.

Biopsy of the lesion was performed May 30, 1935, and the specimen was examined by a pathologist elsewhere. He reported squamous cell carcinoma, Grade 4, which confirmed the tentative diagnosis of malignancy.

Operation—June 3, 1935. Under nitrous oxide and ether anesthesia, a complete block dissection of the lymph nodes of the right side of the neck was carried out by the classical technic. In addition, the right sternomastoid muscle was removed; the jugular vein on this side was ligated, and its trunk, together with all demonstrable lymph nodes in the area, was excised. The left submental and submaxillary lymph nodes were also removed, as were the submaxillary and salivary glands. Immediately after closure of this wound, a wedge-shaped excision of the tumor-bearing portion of the right lip was carried out through an appropriate incision and was followed by plastic repair. Convalescence was uneventful and the patient was discharged in good condition on the ninth postoperative day.



FIG 1.—Section of osteogenic sarcoma of lip removed August 26, 1938, showing spicules of bone in relationship to other cells of the neoplasm. (x80)

The excised tissue was submitted to the same pathologist who had examined the biopsied specimen. He again reported that the tissue from the lip showed squamous cell carcinoma, Grade 4. The lymph nodes showed only inflammatory reaction.

The patient was observed at regular intervals and remained in good condition for the next two and one-half years. In January, 1938, he was admitted to the Medical Service of the Vicksburg Clinic for a cardiac condition which was diagnosed as angina pectoris. He was discharged improved after treatment.

At this time there was no evidence of recurrence of the malignancy.

He was not seen again until August 24, 1938, at which time he presented a bulky recurrent tumor of the lower lip, extending from the right of the midline to the angle of the mouth. There was no evidence of cervical metastases, and roentgenologic examination of the chest revealed no abnormalities. The medical consultant considered the cardiac reserve adequate for surgery.

August 26, 1938, under ether anesthesia, two-thirds of the lower lip was removed *en masse*, and plastic reconstruction was carried out. Convalescence was smooth, and the patient was discharged in good condition on the seventh postoperative day.

In the meantime, the Vicksburg Clinic had established its own Section on Surgical Pathology, and the excised tissue was reported as follows:

The specimen consists of a segment of skin, mucous membrane and subcutaneous tissue from the lip, measuring 5 x 3 x 1.7 cm. Approximately 75 per cent of the specimen is made up of firm, white, fibrous tissue, the cut surfaces of which are slightly gritty. Histologically, the tumor is composed of pleomorphic spindle cells, including many giant tumor cells. Mitotic figures and monstrous bizarre nuclear forms are seen in abundance. Scattered diffusely through the tumor area are many giant cells of the foreign body type, and in several areas are fragments of fibrous osteoid tissue and spicules of true bone surrounded by osteoblastic cells, which shade off into adjacent parts of the tumor (Figs 1 and 2). There is little evidence of hemorrhage or necrosis in the tumor, and the bone formation is apparently a product of the neoplasm rather

OSTEOGENIC SARCOMA

than a result of calcification. Further proof of this assumption is found in the fact that the spicules of bone are rather poor in calcium deposits outside of the osseous tissue. The epithelium of the skin and the mucous membrane evidently take no part in the neoplastic process (Fig 3) *Pathologic Diagnosis* Osteogenic sarcoma

The diagnosis of osteogenic sarcoma was confirmed by Dr A C Bowers of the Mayo Clinic, who kindly examined the material

At this time the microscopic section obtained at the first examination was restudied and a corrected diagnosis of osteogenic sarcoma was made. It was evident, however, that it would have been difficult to make this diagnosis originally, because on the available slide the bone had been torn away by the microtome knife and only small spicules of bone and a defect in the section remained. On restudy of the section, however, osteoclastic giant cells were plainly evident, and the general tumor cell morphology was similar to the morphology observed in the recurrent tumor. As a matter of fact, the pathologist who made the first examinations had previously recognized the unique character of the tumor, since he had called attention to the presence of giant cells and had graded the malignancy 4, which is unusually high for carcinoma of the lip



FIG 2

FIG 3

FIG 2—Higher power view of section of osteogenic sarcoma of lip with spicules of bone. Note the portion of mucous membrane visible in one corner (X125)

FIG 3—Section of osteogenic sarcoma of lip removed August 26, 1938, showing relationship of lobule of tumor to mucous membrane. Note artefact in deeper portion of section, where a spicule of bone has been torn from the tissue by the microtome knife (X55)

When the patient was examined four months after operation there was no evidence of recurrence and his general condition was good. Two months later, however, the tumor had recurred, and fixation to the mandible, confirmed by roentgenologic examination, was observed for the first time.

Second Operation—The affected area was explored March 15, 1939, under nitrous oxide and ether intratracheal anesthesia. An incision through the reconstructed lower lip at the midline was extended laterally to the right mandible and exposed a large mass, which involved both the mandible and the floor of the mouth on the right. The mandible was divided in the midline and the tumor-bearing bone, with a wide area of adjacent apparently normal bone, was resected, together with the affected portion of the floor of the mouth. No attempt at repair was made. The wound was packed and the skin was partially approximated with interrupted silk sutures.

Postoperative therapy, in addition to routine measures, included the use of the

duodenal tube and an indirect transfusion of 500 cc of blood. The patient died 24 hours after operation. Necropsy was unfortunately not permitted.

Microscopic examination of the excised tissue revealed no bone in the areas sectioned, and no attempt on the part of the tumor cells to differentiate into osteoblasts.

COMMENT—One of the most interesting and most curious features of this case is the relatively long period of well-being (more than three years) between the primary operation and the first recurrence, as compared with the rapidity of the second recurrence (within seven months).

Since the tumor involved the mandible at the time of the second recurrence, the question naturally arises as to whether it involved the bone originally. We are quite certain that it did not. All the evidence, including the prolonged period of quiescence following primary resection of the lesion, pointed to a truly extraskeletal character of the lesion, and roentgenologic study at the time of the second recurrence revealed the type of secondary involvement likely to be found in far-advanced cancer of the lip rather than a primary tumor of the bone.

SUMMARY

(1) A review of the literature of extraskeletal osteogenic sarcoma clearly indicates the rarity of this type of neoplasm. To date less than 50 cases seem to have been reported.

(2) The largest number of reported cases originated in the mammary gland, and the next largest number in the thyroid gland. It is quite possible that a few tumors may have been derived from extraskeletal bony deposits, such as calcified hematomas or foci of myositis ossificans.

(3) An additional case of extraskeletal osteogenic sarcoma is reported, and is apparently the first to be recorded in which the growth occurred in the lip. Radical operation was carried out within three weeks after the lesion was first observed, and the patient remained free from recurrence for three years. Radical surgery was again performed, but a second recurrence took place within seven months and death followed operation for its removal.

The authors regret that the article "Primary Osteogenic Sarcoma of the Bladder" by Crane and Tremblay, *ANNALS OF SURGERY*, 118, 871-886, November, 1943, came to their attention too late to be included in the discussion of the literature in this paper.

We wish to express our appreciation to Drs. A. C. Broders and John R. McDonald, of the Mayo Clinic, for their help and encouragement in the preparation of this paper.

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DISCUSSION—DR JOHN C HENTHORN, Vicksburg, Miss The photomicrographs of the tumor Doctor Parsons has just reported demonstrate (1) spicules of bone in the tumor, (2) relationship of spicules of bone to the fibrocytes of the tumor and, (3) the general configuration of lobule of tumor and its relationship to the mucous membrane which evidently takes no part in the neoplastic process At the top of this last slide is an artefact evidently produced by the microtome knife, which tore a spicule of bone from the tissue at the time the section was prepared An artefact of this type appeared in the slide prepared from the first tissue removed from this patient, and evidently prevented the pathologist from making the correct diagnosis of osteogenic sarcoma

COL BRADLEY L COLEY, New York City There is probably more confusion in the diagnosis of bone-forming tumors that arise in muscles contiguous to bursae than to those arising in the breast and lip We have recently seen one in a soldier, involving the soft tissue adjacent to a tarsal bone The section was reviewed by Dr Fred Stewart at Memorial Hospital, who stated that it was a malignant synovium Since they can occur in a bursa or tendon sheath some distance from bone, they could and do, in some instances, resemble quite closely an osteogenic sarcoma Reference has been made to osteogenic sarcoma arising extrasketically We have observed a case which occurred in the muscles of the thigh quite apart from the femur An additional rare case, arising in the pericardium, was found at autopsy at Memorial Hospital This case was reported by Binkley and Stewart in 1940 in an article dealing with extraskkeletal osteogenic sarcoma and pseudosarcoma

I would like to emphasize the difficulty Doctor Parsons mentioned in differentiating these tumors histologically from myositis ossificans I can recall two instances of wide variation of opinion among a number of eminent pathologists One case was thought by three of these distinguished microscopists to be osteogenic sarcoma, but proved to be myositis ossificans The other instance is one which was thought to be osteogenic sarcoma, by the pathologists at Memorial Hospital, and also proved to be myositis ossificans In both these cases radical surgery was fortunately avoided I think one must take advantage of the services of the radiologists, and study particularly the clinical aspects of these cases to avoid unnecessary amputation, which in the past has occasionally been performed for what ultimately proved to be myositis ossificans And I often wonder whether some of the five-year cures of the older literature may not be, in reality, examples of this sort

Doctor Parsons is to be congratulated on the clear way in which he has brought this interesting subject to our attention

DR BARNEY BROOKS, Nashville, Tenn The condition reported by Doctor Parsons reminds me of a case which was operated upon in Vanderbilt University Hospital only a few months ago, in which a small nodular tumor of the lower lip proved on microscopic examination to be a characteristic "mixed tumor of the parotid region," containing bone and cartilage I mention this merely because of the possibility of the tumor reported by Doctor Parsons having had its origin in a preexisting mixed tumor

DR JOHN C HENTHORNE, Vicksburg, Miss (closing) I wish to thank you for your interest in the paper, for Colonel Coley's remarks and for those of the Chairman

Colonel Coley's reference to synovioma is interesting, since tumors of this type are rare and evidently of very serious nature. Several years ago, I encountered a synovioma of the knee joint and looked up the literature at that time. In one paper there were 29 cases collected from the literature, and all had died from metastases of the tumor. Our own case died about 18 months after onset of symptoms. Colonel Coley's case of extraskeletal sarcoma of the thigh is similar to one reported by Wilson from the Bone Sarcoma Registry of the American College of Surgeons, and that case may have been submitted to the Registry by Colonel Coley. It is cases of this type that suggest the possible origin of extraskeletal osteogenic sarcomas from calcified hematomas or foci of myositis ossificans.

The case of osteogenic sarcoma of the pericardium reported by Colonel Coley also suggests the possible origin of tumors of this type from previously established foci of calcification, because such foci do occur in the pericardium.

Colonel Coley's remarks about myositis ossificans are also pertinent. Doctor Geschickter once said that Doctor Halsted and Doctor Bloodgood used to play a game with each other in which one would unexpectedly show the other a slide from a known case of myositis ossificans, and either one would occasionally make an erroneous diagnosis of sarcoma, much to the amusement of the other. If these men had difficulty with the microscopic diagnosis of myositis ossificans, certainly the rest of us should be careful in differentiating extraskeletal osteogenic sarcoma from myositis ossificans.

Doctor Brooks' mention of a mixed tumor occurring in the lip is also pertinent in that he suggests another possible origin for the tumor we are reporting. Since mixed tumors of the parotid gland type occur in other glands, the occurrence of such tumor in the lip is not surprising. Mixed tumors have myxomatous tissue, and less frequently cartilage and bone in their stroma, and since the presence of myxomatous tissue frequently presages formation of cartilage and bone, there is a possibility that some extraskeletal osteosarcomas may arise from myxomatous tissue. Myxomatous degeneration of the fibrous tissue in fibro-adenomas of the breast is also a relatively common phenomenon and since, as we have pointed out, the fibrous tissue of the mammary gland seems to be suitably disposed to the formation of osseous tissue, myxomatous changes of the fibrous tissue may possibly precede this osseous transformation.

In our case, the rapid development of the osteogenic sarcoma had obliterated any traces of myxomatous tissue or mixed tumor that might have been present previously.

THE VALUE OF NONPROFIT BLOOD BANKS FOR CIVILIAN USE AS PLANNED BY THE OFFICE OF CIVILIAN DEFENSE*

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THERE seems to be no limit yet in sight for the amount of plasma required by both the armed services and civilian population. Wide publicity is being given to the often repeated statement that blood plasma outranks even skillful surgery and the sulfa drugs in lowering mortality and morbidity from casualties of battle, and, the experience in handling shock and especially burns in civil life seems to confirm that statement. This, therefore, means that the demand for blood and plasma reserves for use by civilians will continue to increase.

Donor procurement by the American Red Cross and commercial laboratory facilities for preparation of plasma for the armed services is already taxed to the limit. Everyone agrees that the armed services must come first, but civilian needs cannot be neglected. To meet these requirements, the Office of Civilian Defense and the U. S. Public Health Service have worked out a program. Volunteer donors are being used to build up community plasma reserves, and hospitals are processing blood on a nonprofit basis. No limit is yet in sight for the amount of plasma required. Unless some substitute for human blood is found, it will tax the hospitals of this country, even with all-out community support, to supply that demand.

On June 30, 1943, when the appropriation provided by the U. S. Public Health Service terminated, O. C. D. grants had been made to 168 hospitals, which have pledged 79,000 units of plasma. In addition to this, other hospitals operating blood and plasma banks independently have placed their plasma reserves (about 3,300 units) under control of E. M. S. of O. C. D. There are at present available 160,000 units of plasma stored in 675 storage depots in 382 cities of the United States.

To quote from a paper recently read before the A. P. H. A., Dr. John B. Alsever, Chief of Blood Plasma Section, O. C. D. states: "Today there is no question of the tremendous value of plasma in saving the lives of persons who have been seriously injured, whether it be on the battle fronts or on the home front. It is now known that in all severe injuries there is a loss of circulating blood volume into the injured tissues as well as loss by hemorrhage. This causes the circulation to become inadequate, resulting in tissue anoxia and shock. The shock state may terminate in death if adequate prompt treatment is not given. If the blood volume is restored within a few hours after the injury and maintained at an adequate level, an individual

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can recover from very severe trauma. The special value of plasma is that, like whole blood, it restores blood volume physiologically, except for the red cells which have been lost through bleeding. Unlike whole blood, it can be made available in large amounts, can be stored over long periods of time, and can be administered without reference to blood group, cross-matching, or skin-testing. Plasma, like whole blood, is far superior to salt solution, glucose, or acacia for treating shock.

"It should be emphasized that plasma must not be considered to have completely replaced the use of whole blood in the treatment of shock. In fact, if it is immediately available, whole blood is preferable to plasma if the shock is due to hemorrhage. However, even in a case of severe hemorrhage, plasma in adequate amounts is life-saving and should be used if whole blood is not immediately available, for this can always be given later on. A person cannot survive long without a blood volume large enough to maintain adequate circulation, but he can survive a severe degree of anemia.

"Unfortunately there is no rule or formula by which one can determine the amount of plasma necessary in a given case. The only safe and practical procedure is to give enough plasma to achieve the desired result, namely, restoration and maintenance of normal blood volume. Time does not allow for a detailed discussion of dosage except to say that a severely burned person may require three to six liters of undiluted plasma in the first 72 hours, and that at least one to 1.5 liters are required in cases of severe injury.

"Since April, 1942, when the Public Health Service began this plasma program, over 5,000 units of plasma have been used by the gantee hospitals in the treatment of their regular patients as well as the victims of civilian disasters. The excellence of the technic employed by these hospitals in preparing and administering plasma is evidenced by the fact that they have experienced less than 1 per cent of reactions with its use. These have been of the pyrogenic or allergic types, which are rarely severe. The number of reactions reported is very close to the irreducible minimum which may be expected to accompany the intravenous administration of fluids.

"The plasma reserve and the organization for distributing it have proven their value many times. One of the first incidents in which these reserves were used was the Coconut Grove disaster in Boston. In all, 1,308 units of plasma were used to treat 181 burned patients, most of whom lived. Their survival was due, in large part, to the prompt administration of adequate amounts of plasma. Of the plasma used, 833 units came from the Civilian Defense reserves in Boston, which amounted to 2,800 units at that time. The remainder was supplied by the U. S. Navy and the Red Cross.

"In Rochester, New York, 57 units of plasma were used to treat 15 workers injured in an explosion at the Rochester Fireworks Company. Five workers burned in an explosion at the Tidewater Oil Company plant at Bayonne, New Jersey, required 24 units. Some of the other incidents in which these plasma reserves have been used are: The crash of a bomber into a Seattle, Washington, packing plant, an explosion in a munitions plant

at Elkton, Maryland, a war plant fire at Amsterdam, New York, the explosion at the Congoleum-Nail plant in Kearney, New Jersey, the wreck on the Pennsylvania Railroad at Philadelphia, the Lackawanna Railroad accident at Wayland, New York, and the hotel fire in Houston, Texas

"On several occasions plasma has been supplied to Army, Navy, and Coast Guard stations in this country to meet an emergency when their own plasma was not immediately available in sufficient quantity. Such a case occurred last May, at Abilene, Texas, when a column of soldiers marching at night was run through by a motorist. Plasma was requested at about 1 A.M. from one of our grantee hospitals at Fort Worth, and was delivered to the Station Hospital, 150 miles away, by the Civil Air Patrol within one hour after the request was received.

"The establishment and operation of blood and plasma banks in the larger hospitals has proven to be of great value in improving the treatment of the sick and injured. Although the most spectacular results are seen in the treatment of traumatic and burn shock, the ready availability of blood and plasma is resulting in better preoperative preparation of surgical patients who show decreased plasma proteins or anemia. Likewise, the adequate and prompt replacement of the blood loss which accompanies major surgery, prevents shock and keeps the patient in excellent condition during the operation. This permits the longer surgical procedures to be carried out without the need which so often exists to 'finish the operation before the patient goes bad.' Further transfusions of blood or plasma are often indicated during convalescence because of continued anemia or depletion of blood proteins. Convalescence is smoother and shorter when the blood components can be kept within normal limits. The blood bank also facilitates the treatment of the anemias, blood dyscrasias and acute infections.

"It is my belief that hospitals, equipped to prepare plasma and store plasma in the frozen state, will find increasing use for it in the treatment of infectious disease."

It is definitely the responsibility of the medical profession and the hospitals to give all-out support to both the Red Cross donor procurement service for the armed forces and to the independent program of the Public Health Service and the Office of Civilian Defense. No greater service could be rendered in support of the war effort and surely, the urgent need for blood plasma, during and after the war is manifest.

Blood *purchased* from donors and processed on a commercial basis is too small in amount and far too expensive to meet civilian needs. The Civilian Defense program now being operated in conjunction with U.S. Public Health Service seems to offer the best available means for meeting the rapidly expanding civilian need, but without the active support of the medical profession, hospitals and full cooperation by federal, state and local health agencies, the press and the general public, even the excellent O.C.D. program now in operation, under the able leadership of Doctor Alsever, will be inadequate.

DISCUSSION—DR CHARLES R EDWARDS, Baltimore, Maryland I happen to come from the State of Maryland which, under the administration of our late Governor, was a free state, I do not know its exact status now I want to say something in support of Doctor Russ' contention Of course you know that the Red Cross has provided great quantities of blood plasma and in Maryland, of which state I happen to be Director of Emergency Medical Service, we have made an attempt to develop existing facilities and to employ no new agencies With that in mind, all hospitals in a position to do so were asked to develop their facilities for processing blood—frozen or dried plasma, *etc* We have gone a little further and worked for all our demands for blood Hospital officials and public health officers throughout the state have formed a committee and attempted to line-up a great many people who might, on sudden call, be asked to donate blood Everybody who goes to a hospital to donate blood for relatives or friends is asked to go on this list The blood is typed, a record is made, and the individual gets a duplicate card A letter is written him asking that he have his name put on the official roster, and if an emergency comes a request is sent to him to report to the hospital nearest which he lives So far there have been no refusals, and by the end of this month we will have 50,000 people on this list

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MEMOIRS

SIR WM ARBUTHNOT LANE, BART , C B , F.R C S

1856-1943

SIR WM ARBUTHNOT LANE was born at Fort George, Inverness, Scotland, July 4, 1856, and died in London, January 16, 1943, at 86 years of age, the son of Brigade Surgeon Benjamin Lane, Lic R C S Ireland, and was



educated at Stanley House, Bridge of Allan, Scotland. He received his Bachelor of Medicine (M B) and Master of Surgery (M S) from London University, followed by the usual F R C S England.

He qualified from Guy's Hospital when he was only 21, and less than ten years later was appointed surgeon to Great Ormond Street Hospital, and then to the staff of Guy's Hospital, where he attained his greatest prominence.

He was created baronet in 1913, Comp Bath in 1918 F A C S (hon) in 1925, Chevalier of the Legion of Honor, *etc*

He had visited the United States frequently, and in October, 1925, came especially to deliver the annual Murphy Oration at the Clinical Congress of Surgeons held in Chicago that year. He was at that time close to his seventieth birthday, and about to retire from active service at Guy's and at the Great Ormond Street Hospital for Children, where he had been the center of attraction for over a quarter of a century, especially to American medical tourists, who flocked to his clinic and regarded no visit to London complete without paying him a call and seeing him operate. These friendly relations made him sure of a cordial reception whenever he came to the United States, especially on this visit to Chicago, where he was to reap the laurels of an international friendship which had been planted and cultivated for over three decades.

An anatomist and surgeon by inclination and long culture, his authority had been long recognized since early years, when he published an excellent anatomical guide, made particularly valuable because of its surgical applications. He had also become an authority in osteology because of his notable thesis in which he particularly studied the changes in the skeleton consequent on the stress and strain to which it is subjected by different occupations, illustrating his observations by detailed studies of the anatomy of the coal-heaver, the shoemaker and the chair woman, out of which his general conclusion still remains true to the effect "that we bear a simple mechanical relationship to our surroundings. Any change in that relationship produces a corresponding alteration in our anatomy."

In his early years he also became notable by his successful ligation of the internal jugular vein to prevent metastatic infection of the lungs from septic lateral thrombosis following middle ear and mastoid disease. Previously this procedure had been suggested and carried out in one instance by Victor Horsley, who performed the first jugular ligation for this cause in 1888. Lane following immediately in 1889. These and other original innovations soon led to his appointment as Chief Surgeon at Guy's and at the Great Ormond Street Hospital, where he held sway until the day of his retirement.

His thorough anatomical and physiological foundation made him a bold and yet safe operator, original and resourceful, and always imperturbable in his calm, British self-possession. He seemed to know no limit to the anatomic regions over which he practiced his art. He was as much at home in dealing with the extremities as in the head, neck, and trunk, in the joints and bones, in extirpating the colon, or doing a cleft palate, in ligating and excising the internal jugular vein to check an acute otitic infection on its fatal way to the lungs.

In one morning at Guy's I saw him do an unusually difficult palatoplasty for cleft palate in a small child, a resection of the lower jaw for malignant disease, an open reduction and plating of both bones of the forearm for fracture and a total colectomy, from cecum to sigmoid with a terminal

ileosigmoidostomy, by his method of anastomosis—for the relief of what is still known as “Lane’s disease” Upon all these operations he stamped the seal of his personality by the originality of his procedures and the smoothness, ease, and perfection of technic that proclaimed a real master, a master who dared where others quailed and who succeeded where others would have failed without his skill, his precision, and the confidence with which he planned and executed his operations

His special interest in the anatomy and pathology of the skeleton led him to direct his attention to the treatment of fractures and to his dissatisfaction with the results obtained at that time with the classical modes of treatment Lane’s early contention and insistence that the surgeon should do as neat a job “when repairing broken bones as a cabinet maker in mending the legs of broken chairs,” was the starting point of his early pleading (*Lancet*, May 26, 1901) for more thorough and perfect adjustment of broken bones With the dawn of asepsis and the advent of the roentgen rays, the open treatment of fractures became a possibility, which Lane soon converted into a habit—and even into an obligate routine—whenever the classic methods of closed reduction failed to bring the broken bones into perfect apposition

Lane’s Plates and the Open Treatment of Fractures—To accomplish this purpose, Lane invented the perforated steel plates which were screwed to the bones and allowed to remain permanently embedded The simplicity of this procedure and the ease with which it generally accomplished its purpose, immediately gave Lane’s plates a warm reception all over the world

The story of Lane’s plates and their vicissitudes is too well known to justify rehearsal here Suffice it to say that, though it appeared for a while that Lane’s plates were destined to the same oblivion that ended the glory of the Murphy button, they have not only survived all the criticisms to which they have been subjected, but are now serving their purpose in many modified forms and ways, far beyond Lane’s most sanguine expectations A better knowledge of their indications and especially the introduction of the neutral metal vitalium by Venable, of San Antonio, as an alloy which is practically inert in the tissues—now used as a substitute for Lane’s earlier steel plates—has not only rehabilitated the Lane plates, but has made them in principle one of the outstanding contributions to the advance of bone surgery

Perhaps no more striking illustration of the diversified effects of Lane’s principle in the development of bone surgery could be quoted, than the magnificent triumph achieved by Surgery in solving the problem of the broken hip (fractured neck of the femur) which for centuries has challenged the best of surgery to make this rebellious fracture amenable to its curative laws Here we see contemporary surgery’s most brilliant accomplishment in redeeming thousands of helpless crippled men and women all over the world, now happily restored to independence and usefulness by the skillful application of Lane’s practice as applied and interpreted with great originality and ingenuity in America by surgeons such as Smith-Peterson the pioneer, and his host of followers in the orthopedic and surgical ranks Suffice it to consult

the textbooks of the last quarter century to realize what a tremendous distance we have travelled in the treatment of broken bones since Lane led the way to the goal

Lane not only gave a new outlook to the treatment of fractures, but he created a veritable renaissance for the mechanical therapy of skeletal traumas by the impulse he gave to the invention of innumerable instruments for the open reduction of fractures that now fill the catalogues of surgical instrument makers, including the large fixation clamps on which he depended to obtain an absolute control of the broken fragments while screwing on his plates. He used no extension tables or apparatus to relax muscular spasm or to bring the bones into apposition, depending solely on sturdy assistants to handle and steady the limbs until he had obtained the perfect fixation of the broken ends

One of the striking features of Lane's bone instruments was the great length of their handles, which permitted all the work of reduction and bone plating to be done without manipulation in the wound itself. The procedure which he described as "no touch technique" aimed at the avoidance of infection from leaks in gloves and other sources. He had acquired great dexterity in working outside of wounds by constant performance with these tools, a dexterity which he also required of his assistants. He was satisfied with this technic, which gave a special cast to his armamentarium, and contributed no little to the aseptic results of his bone surgery. There is no better tribute to the excellence of his performance than the results recorded in his book, "Operative Treatment of Fractures" (2nd edition, 1914) which records the unique and unsurpassed experience of 22 years in the application of his methods

Intestinal Stasis Colectomy—Early in his surgical career Lane became impressed with the importance of the intestinal tract as a source of chronic intoxications resulting from dietetic errors. He became a firm believer in Metchnikoff's teachings, which led him to say that it was no exaggeration "that we suffer and die through the defects which arise in our sewerage and drainage system,"—an opinion which was accentuated by Pauchet of Paris who, after Lane, was the most experienced in successful colectomies in Europe, and who added that "intestinal stasis was the cause of nearly all the pathology of civilization." Lane was absolutely convinced that chronic intestinal stasis was the cause of cancer of the colon and even elsewhere especially when stasis was aggravated by mechanical obstacles in the path of the fecal current, such as a kink in the bowel caused by adherent or acquired peritoneal bands, thereby causing friction and irritation at the point of obstruction. It was here that the "Lane kink" figured large as a permanent cause of colonic morbidity, and it was the kink in the right colon and at the sigmoid flexure that Lane so insistently described, and that kept radiologists busy for many years demonstrating it to surgeons who were kept still busier for many more years performing celiotomies to straighten it out

The kink and stasis predisposed to the elongation and to the prolapse

of the bowel and the viscera (viscero- and enteroptosis), "to rheumatoid arthritis, tuberculosis, arteriosclerosis, to epilepsy, and above all to cancer" The difference between chronic intestinal stasis and plain constipation was that in chronic intestinal stasis the stagnant pool of feces in the colon became definitely infected with pathogenic germs which brewed the toxins which were absorbed and carried everywhere in the organism by the circulation In this way the familiar picture of visceroptosis and its usual accompaniment, cardiovascular asthemia, *etc*, evolved into the protean picture which was identified as "Lane's disease"

It is from this pathologic background that the operation of *radical* or *complete colectomy* was evolved, which Lane conceived as the only possible remedy for the disease before it reached its terminal stages, and it was based on this conviction that Lane performed colectomies more frequently and for more numerous indications—but far more perfectly and successfully—than any other surgeon in the world

To those who, like the writer, have watched Lane perform a total extirpation of the colon, his very small operative mortality was not at all surprising One could not see Lane perform this exacting and technic-testing operation, without feeling that he had seen something done as well as it could possibly be done Lane's incomparable perfection as an abdominal technician in this special field was based largely on the following distinct features (1) Free incision, permitting adequate exposure of the abdominal contents, their inspection and palpation (2) Speed without haste Lane did not strike a casual observer as a rapid operator, yet the colon was removed from cecum to sigmoid, the terminal ileosigmoidocolic anastomosis performed, and the peritoneum closed, well within an hour But this could not have been possible without making every act purposeful and in uninterrupted continuity, and the entire absence of haste (3) Lane made a real advance in intestinal surgery when he showed that the large intestine could be joined to the small without risk by an end-to-end anastomosis He showed that this actual anastomosis possessed no special risks, and had every advantage over an end-to-side ileocolostomy, which had to be abandoned because it failed to obviate the objectionable and dangerous regurgitation of the fecal current into the blind end of the colon, causing its enormous distention and compelling a colostomy for its relief (4) Another important feature of his technic was insertion of a rectal tube through the anus to a point in the ileum well above the anastomosis for the purpose of preventing flatulent distention above the line of the ileocolonic joint Furthermore, he was ahead of most of his British contemporaries in his effort to prevent postoperative shock and dehydration by preceding the operation and continuing it under the steady flow of a saline solution by hypodermoclysis, a procedure known in his clinic as the 'axillary sup,' which we carried on in our clinic in New Orleans for the same purpose by the continued intravenous glucose-saline drip

Lane was so impressed with the view that cancer and the great bulk of diseases in civilization were due to errors of diet and improper feeding that

he founded "A New Health Society" which was organized essentially as a crusade for the prevention of cancer—a prophylactic aim which could only be made effective by complete revolution in the food and dietetic habits of the people

Lane was so enthusiastic in his concept of the dietetic origin of disease, and especially of cancer, that he retired from his surgical practice, in which he had attained the greatest eminence, seemingly without regret, to assume the direction of the "New Health Society" which he had founded and organized, and which, if it had ultimately succeeded in its purpose, would have deprived surgery of some of its most heroic chapters, including some of Lane's greatest triumphs

In conclusion, we may truthfully say that Lane expanded the surgical horizon by directing the profession to new surgical possessions and achievements (open reduction of fractures and fixation with Lane plates, intestinal stasis and Lane's kink, perfected colectomy technic, Lane's operation for cleft palate and pioneering in jugular ligations to prevent pulmonary metastases from ear infections) many of which we are now cultivating with profit and the promise of still greater benefits. Whatever may be the ultimate destiny of Lane's later concepts and theories regarding dietetic errors as predisposing to intestinal stasis, cancer, and other disorders that afflict civilized man, we know that these theories were conceived in good faith and with profound conviction of their truth, and that even if they have not been confirmed in all his conception of their importance, they have left a residue of value to the future, as the result of their discussion and controversial agitation. With us as surgeons, his memory will remain conspicuous and radiant, as that of a great practitioner of our art, a real virtuoso, a magnificent technician, and a pathfinder whose name will remain honored and indelible as that of a man who made surgery better by his presence and his deeds.

He was married twice, first, in 1884, to Charlotte, daughter to John Briscoe, with whom he celebrated his golden wedding, and later, to Jane, daughter of the late Mr. N. Mutch.

He leaves a son, William Arbuthnot, who succeeds to the title, and three daughters.

R. MATAS, M.D.

GEORGE CRILE

1864-1943

To write the obituary of an intimate friend is a difficult assignment, in any case, and the task is particularly hard when that friend was George Crile. The easiest way would be to compile the usual dates, to list his positions, to cite his military service, and to append a list of his awards, honors and publications. These activities and achievements are so well known to members of the medical profession however, that I shall leave it to others to assemble the record. I

prefer rather to comment on him and his work, as I knew him throughout a lifetime of close personal and professional association

He had a unique personality, and doubtless would have been an outstanding figure in any profession. With his personal charm, his keen intelligence, his handsome bearing, his abundant energy, and his zest for knowledge, he could not fail to succeed in anything he might have undertaken. Fortunately for our profession he chose to devote to medicine and surgery his talents and energies



and his enthusiasm. Perhaps enthusiasm was his dominant characteristic, for he never did anything he could not do enthusiastically. His abundant zest was infectious, and spread to those who worked with him and to his patients. As a physician he had an almost mesmeric quality in relieving the anxiety of the sick.

His skill as a surgeon needs no comment. His dexterity—in fact, ambidexterity—and sharp clean dissection were inspiring to a whole generation of students and surgeons who observed his work in the operating room. As a surgeon he had the confidence born of skill, and the imagination and courage to attempt procedures that carried risk, if he felt that they might be successful in alleviating suffering or prolonging life.

Above all, though, George Crile had a quest and a vision that he pursued throughout his entire adult life with a devotion amounting almost to mystic fervor. This is the striking thing that distinguished him from other surgeons and that gave special meaning to his life. He was not content to make use of

known truths, but was forever searching for the answer to "What is Life?" This was the stream into which his tremendous energies flowed, and all his activities and observations were purposeful and tributary to this.

As a practicing surgeon, he knew at first-hand the barriers and obstacles created by the unknown, so he devoted his life to trying to extend the frontiers of knowledge that would help in solving surgical problems. It was apparent to him immediately that many of these problems could not be solved merely by accurate diagnosis and technical skill. They could be conquered only by an understanding of the processes of life and death. Hence, his activities were directed to investigation of these fundamental questions, because he knew that they would provide the answers for many specific surgical problems.

He never ignored an opportunity to learn from evidence at hand. Always he was observing, recording, correlating, devising theories and planning experiments to substantiate them. No observation was too insignificant to engage his attention, if it offered some small clue to the answers he was seeking. In conversations and discussions with his colleagues he was alert to grasp any chance remark that might have a bearing on the problem he was studying. Thus his work never degenerated into routine for he was always the investigator.

During his earliest years of medical practice, he made detailed observations on his cases and kept careful records, with special emphasis on the results of shock. He eagerly embraced every opportunity to learn more about it. In one of his earliest records, he describes an operation he performed on a severely injured patient who died while he was operating. In the case history one reads the notation "The operation gradually merged into an autopsy."

The stress of his duties as surgeon and teacher was never too great to prevent his continuing the search constantly. On the battlefields of the last war, it was carried forward. This experience gave him the opportunity to engage in studies on shock on a tremendous scale, and he took advantage of it. Later in his life, the search led him to the jungles of Africa, to the frozen North, to make first-hand observations on men and animals of different environment backgrounds. Toward the end of his life, when he was seriously injured in an airplane crash, he calmly made observations on himself and others and directed first aid measures, although he was unable to move from his seat. Still later, when he was handicapped by physical infirmity, he continued his laboratory investigations, and in his last illness, he observed his own subjective symptoms with the same intellectual detachment and curiosity with which he had observed so many others, and to his last conscious moment he was seeking the answer to the questions pertaining to life and death.

He early came to the belief that the function of all living things could be explained on a biophysical basis and that life was an electrochemical mechanism. On the basis of this theory, he likened human function, in its most elemental form, to a battery that could be charged and discharged. When the capacity for recharging was destroyed, or if, for any other reason, there was no difference in the electrical potential death ensued. Hence he set out to

investigate various factors that would discharge and exhaust the function of life. This led to his researches on sleep and physical measurements of effects of various injuries and drugs particularly anesthetics. It also led to his investigations on the properties of cells.

Perhaps the greatest contributions he made to surgery were in the field of anesthesia, and in development of the principle of anoci-association, as it pertains to the reactions and response of the patient, both physically and psychically. He had shown that animals could be exhausted, even to death, by depriving them of sleep. He also observed similar phenomena in soldiers during the last war. The same effects could be observed following various methods of traumatism in animals, even under complete anesthesia. He had also observed the shock-producing effects of prolonged ether anesthesia. All these experimental and clinical observations were correlated in the development of combined anesthesia with nitrous oxide and oxygen and narcotics, known as anoci-association, a method that is forever applicable in the treatment of the sick.

His later researches were concerned particularly with what he called the kinetic system—the brain, thyroid, heart and adrenal glands—and he made comprehensive observations comparing the findings in numerous species having different energy requirements and in studying metabolism in various types of primitive peoples and comparing it with that in the more energetic peoples of civilized communities. Late experiments also were concerned with the measurement of electrophysical processes in different tissues under varied conditions.

All these experiments and activities and his clinical and surgical observations were correlated into the large program of investigating the fundamental life processes. While he did not succeed in finding detailed answers to all the questions concerned, he did make many valuable contributions which will aid others in coming yet nearer the truth. When he died, he had the satisfaction of the conviction that his work had been directed in the right channel, for in all his observations, within and without the clinic, of the normal and abnormal phenomena presented by man whether physical or psychologic, he found nothing that he felt was incapable of explanation by biophysical laws. Some of those laws remain yet to be found, but George Crile made fundamental contributions in this field of knowledge, and perhaps more than anyone else appreciated and publicized the importance that fundamental researches of this kind have in practical clinical and surgical practice.

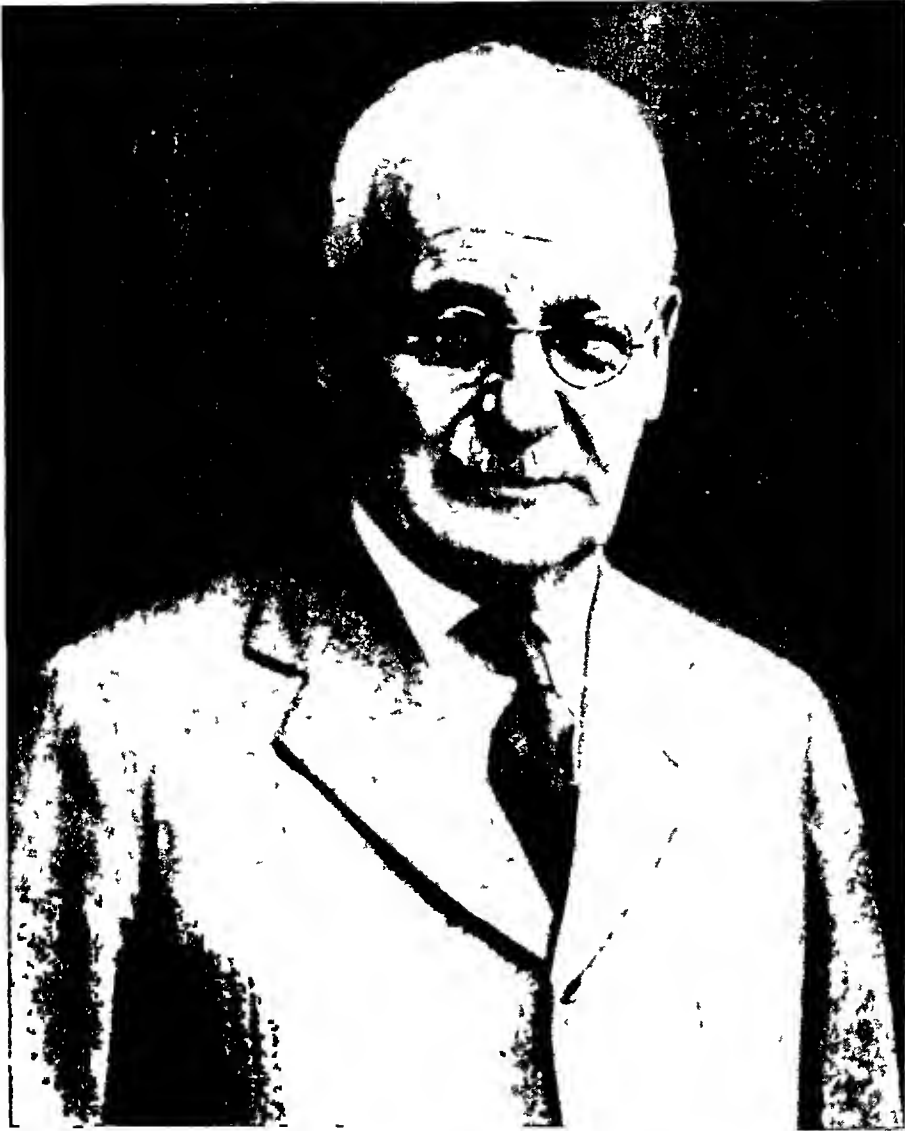
He gave a lifetime of service in the care of the sick, he left the indelible mark of his personality and ideas on a great medical school and on the private clinic he helped to found. He prepared hundreds of students to practice surgery and inspired many of them to an interest in investigation and research. He also served his country with distinction in World War I, and in the present war in an advisory capacity. It is given to few men to do more with a life or to leave a finer heritage.

WILLIAM E. LOWER, M.D.

JOHN MILLER TURPIN FINNEY

1863-1942

Beautiful appreciations of Dr John M T Finney written by Dr William A Fisher, Dr Arthur M Shipley and Dr Harvey B Stone have appeared in different publications, and little can be added to what they have already said. I have used these splendid tributes freely in preparing this memorial.



To those of us, who have had the privilege of coming under the direct influence of Doctor Finney through the years, as students, as interns, and later as colleagues and friends, his passing on May 30, 1942, after a long and very successful life was a great personal loss.

There is little doubt but that his flawless ethics, his kindness and consideration of the patient, regardless of race, creed or color, his sympathy, his con-

summate skill, his gentleness, his patience, his tact, his thoughtfulness, his sound common sense and judgment in dealing with his patients and also with his professional colleagues, made a profound impression on those who came in contact with him

Doctor Finney was born June 20 1863, on a plantation near Natchez, Miss He was the second son of the Rev Ebenezer Dick Finney, a Presbyterian minister, and Annie Louise Parker Finney At the time of his birth, his father was pastor of the Greenwood Presbyterian Church near Natchez, Miss His mother died when he was five months old, and he was taken into the family of a close friend, Mrs Stephen Turpin, where he lived for three years Then after the Civil War was over, he went to his maternal grandmother's at Winchester, Ill, where he stayed until 1871 and then to his paternal grandfather's home at Churchville Md His father later became pastor of the Presbyterian Church in Bel Air, Md, which is near Churchville, and Dr Finney lived there attending the Bel Air Academy until he entered Princeton University He graduated from Princeton on June 20 1884, on his twenty-first birthday, and having always desired to become a doctor entered Harvard Medical School in the Fall of the same year The Medical course was three years, but on account of illness, he lost a year and did not graduate until 1888 when he was given an appointment on the Surgical Staff of the Massachusetts General Hospital, and his degree was awarded in 1889

Desiring to return to Maryland, he was advised to see Dr William S Halsted, Chief Surgeon of the new Johns Hopkins Hospital By appointment, he met him on May 7 1889 on which day the hospital was formally opened He was immediately given an appointment by Dr Halsted on the Surgical Staff to take charge of the Surgical Dispensary

Dr Finney spent eighteen months on the Surgical Service of the Massachusetts General Hospital and then was released before his service was completed in order to accept his appointment at the Johns Hopkins Hospital At the Massachusetts General he came under the influence of such distinguished surgeons as Dr C B Porter Dr John Homans and Dr Arthur T Cabot

On coming to Baltimore Dr Finney became associated with the beginnings of the Johns Hopkins School of Surgery, which was founded by Doctor Halsted, and Doctor Halsted's influence on him was profound He admired Doctor Halsted very much and described him in the Hunterian Lecture he delivered in London January 17, 1927, as "The greatest American surgical teacher"

The aseptic method of sterilization by heat was beginning to replace the antiseptic solutions and the spray in surgery and at the Johns Hopkins Hospital asepsis superseded antiseptics Doctor Finney became an enthusiastic advocate of Halsted's methods and did much to advance the practical use of the principles developed by Doctor Halsted He also made many contributions of his own, and during his entire career kept fully abreast of the advances in scientific and clinical surgery and had the unfailing ability to separate the wheat from the chaff He was married by his father on April 20 1892 to

Miss Mary E. Gross, a member of the first class in the Johns Hopkins School of Nursing, and their marriage was a very happy one in every way. Mrs. Finney and four children, Dr. John M. T. Finney, Jr. and Dr. George Gross Finney, both outstanding surgeons, Eben D. Finney, an architect, and a daughter Mary, Mrs. James S. McDonnell survive him.

When the careers of many great men in medicine and surgery, who have passed on, are looked up, it is frequently found that there is little on record of the kind of men they were, how they lived, how they thought and how they looked, nothing being recorded except their scientific contributions. It is fortunate indeed for his friends and for the benefit of posterity that Doctor Finney published in 1940 his autobiography, "A Surgeon's Life." In addition there are very fine portraits of him: one in his academic robes which hangs in the Johns Hopkins Hospital, was painted by Harold Knight, the English portrait painter. Another portrait, which was painted by Thomas Corner of Baltimore, hangs at the Union Memorial Hospital. Both of these portraits are speaking likenesses.

One had only to look at Doctor Finney to know the kind of man he was and his presence inspired admiration, affection, and a sense of confidence and security to his patients and to his friends.

Although Doctor Finney was from the time he came to Baltimore until Doctor Halsted's death second in rank on the Surgical Staff of the Johns Hopkins Hospital, for some unexplained reason he was not allowed the privileges of the private or public wards in the hospital for many years. In consequence as his private practice increased, it became necessary for him to have some hospital where he could send his patients and operate upon them. He selected the Union Protestant Infirmary, an old institution which in due time, under his stimulating influence and that of a carefully selected visiting staff, developed into a very active hospital, the majority of the work being surgical in character. The popularity of the hospital increased tremendously and in order to obtain a larger bed capacity and to move into a more suitable neighborhood a campaign was started after the first world war was over in 1919 with Doctor Finney as chairman to collect funds for a new hospital to be called the Union Memorial Hospital. The success of this campaign was largely due to Doctor Finney's efforts, and the present fine institution has justified his far vision. The operating suite at the Union Memorial Hospital is called the J. M. T. Finney Operating Suite. Doctor Finney remained the outstanding member of the staff to the end and the hospital was often spoken of as Doctor Finney's Hospital.

Doctor Finney was a charming companion and a delightful raconteur. No one who had the opportunity to listen to his Negro stories which he loved to tell, and told very well, will ever forget them. He had a rare sense of humor, and many of us will long remember some of his impromptu remarks in his discussions with John Deaver, Charlie Mayo, and others. He had a powerful physique and a prodigious capacity for work. He never seemed to tire and was able to go on effectively after a hard long day when his assistants were all in. He always believed the best of a man and sometimes this

was taken advantage of. His patience and tolerance were beyond belief, and on several occasions, some of his friends felt that a little less patience would have been advantageous to everyone.

The spirit of good feeling and cooperation, which is so outstanding among the medical profession in Baltimore, which has been so noticeable for many years, was largely due to the influence of Doctor Osler and in an equal degree to Doctor Finney.

On the death of Doctor Halsted in 1923, Doctor Finney was appointed Acting Professor of Surgery and Chief of Service at the Johns Hopkins Hospital and Medical School, which position he held until the appointment of Dr. Dean Lewis in 1925. Ultimately, when he retired at the age of 70, in 1933, he was made Emeritus Professor of Surgery. In 1917, he went to France as Director of Base Hospital No. 18. He was soon made Chief Consultant in Surgery, A. E. F. with the rank of Colonel, and later was made Brigadier General. His outstanding services were largely responsible for the effectiveness of the surgical care of the soldiers in France. He was awarded the Distinguished Service Medal, Officier de la Legion d'Honneur (France), Commander de l'ordre de la Couronne (Belgium).

Many honors were conferred upon him because of his distinguished position in the surgical world. He was lecturer and Honorary Member of the Hunterian Society of London, 1927. He was Bigelow Lecturer in Boston in 1932 and received the Bigelow Medal for "Achievement in Surgery." He was honorary member of the Medical Society of London, Royal College of Surgeons of England, of Ireland and of Edinburgh. Honorary LL.D.'s were conferred upon him by several universities. He was one of the Founders and the first President of the American College of Surgeons, 1913-16, and was closely associated with the organization for many years. He was a member of the American Surgical Association (President 1921), the Southern Surgical Association (President 1912), the Medical and Chirurgical Faculty of Maryland (President 1934-35). Founder member of the Society of Clinical Surgery, and was a member of the Eclect Club and other surgical organizations.

Doctor Finney was particularly enthusiastic about the Southern Surgical Association, and rarely missed a meeting. Some of his best papers were read before this association, and many of us remember well his brilliant and witty discussions.

In recognition of his services to the Medical Corps of the Army during World War I, the large U. S. Army General Hospital at Thomasville, Ga. has been called the J. M. T. Finney Hospital.

Doctor Finney was very much interested in education, as can be shown by the fact that he was a life trustee of Princeton University. (When Woodrow Wilson was made Governor of New Jersey, he was offered the Presidency of Princeton, but declined.) He was trustee of Lincoln University, he was trustee of Princeton Theological Seminary, he was president of the Board of Gilman School for Boys, he was President of the Board of the McDonough School. At one time he was a member of the School Board of Baltimore and until his death was a member of the State Board of Education. He was

interested in the betterment of Negroes, and was largely responsible for the conversion and rehabilitation of the old Union Protestant Infirmary into the well equipped "Provident Hospital" for Negroes, where Negro doctors and nurses could be trained and could be given adequate facilities to take care of their own people

Doctor Finney contributed numerous surgical papers, nearly all of which were clinical in nature. He was an ideal clinical teacher, simple, lucid and practical. His surgical judgment, both as an operator and as a diagnostician, was uncanny. At the operating table, he never seemed to hurry but deftness, skill, sureness of method and perfect technic effected careful, rapid, finished work. He was at home in all regions of the body, but in his later years became particularly interested in the surgery of the stomach and intestines and many of the patients referred to him were operative cases of the most difficult kind. Throughout his surgical career, a considerable portion of Doctor Finney's work was entirely free, and in this connection, I very much doubt whether anyone in this country has ever operated upon more doctors, nurses, medical students and ministers, than he has. Although material success came to him in a larger degree than to many men, his fees were always extraordinarily moderate.

Doctor Finney was brought up as a Presbyterian and was prominent in the councils of this church during his entire life. He was a practising Christian who did not try to force his religion on his patients and friends but showed them by his actions and example how a Christian gentleman should live. He was modest and unassuming but had very definite opinions. He was fearless and had the courage of his convictions. He was keenly interested in sports, particularly those of his alma mater and was frequently seen at football games. He played left end on the Princeton team when in college and on the Harvard team during his first year in the Medical School. As far as the records show he is the only man who ever played on both the Princeton and the Harvard football teams. He also enjoyed hunting and fishing, and was an all around real man. He was always interested in reducing the cost of hospital care for people of moderate means, and it was through him that Mr. Frederick Bauernschmidt built the Frederick Bauernschmidt Memorial Building on the grounds of the Union Memorial Hospital and this was the first building for this purpose erected in this country. He had a genius for friendship and a great number of devoted friends and admirers in every walk of life, who surely miss his always ready willingness to help and give advice.

Doctor Finney was always interested in public affairs and served on many city and state commissions. He was mentioned as candidate for governor and for U. S. Senator from Maryland but declined both. He was at one time Chairman of the Community Fund, and was for several years and up to the time of his death, Chairman of the Baltimore Chapter of the American Red Cross. He was Chairman of the National Conference of Christians and Jews in Baltimore and gave his time and influence toward the furtherance of this important movement. Without question at the time of his death Doctor Finney was the foremost citizen of Maryland.

Anyone who was taught by Doctor Finney or who worked with him, unconsciously absorbed some of his qualities and methods, and there are many outstanding surgeons in this country today, who owe their success to his teaching and to his example. I feel there is no one in the surgical world, who has had a more profound influence for the good, both professionally and as to what was right and what was wrong than Doctor Finney had.

It is difficult for those, who did not know Doctor Finney, to understand how all of the qualities which I have mentioned, could be concentrated in one man, who was so modest and unassuming, but they were there in full measure.

Had Doctor Finney lived three weeks longer, he would have been 79 years old, and while during the last two or three years, he had gradually cut down on his operating, he had kept up his other interests and activities as keenly as ever. His death robs the country of a Master Surgeon of international reputation and an outstanding teacher, clinician, and diagnostician, an honest generous fearless citizen, a wise counsellor, a sincere Christian and one who has been an example and an inspiration to the entire medical profession for many years.

JOHN STAIGE DAVIS, M D

MONT ROGERS REID

1889-1943

On May 11, 1943, Mont Rogers Reid died at his home in Cincinnati after a short illness. He was only 54 years of age, and had been extremely active up to the time of his death. In fact, his unselfishness in giving his time and effort to his varied interests of teaching, of contributing to medical knowledge, of managing his busy Surgical Department, and of being the "beloved surgeon" to the community which he loved, contributed to his untimely death.

He was born in Oriskany, a tiny village in the Virginia mountains, on April 7, 1889. His early education was given him by his father who took upon himself the strenuous task of teaching his six sons. After two years of preparatory school, he entered Roanoke College and received his A B degree in 1908. Later in life he delighted in recounting stories of his youthful escapades, of the obstacles which he and his family had to overcome, and of the interesting characters who lived in the simple mountain community. Throughout his life he went "down home" as often as he could, fished the streams, hunted in the hills and renewed his old friendships. The calmness, the simplicity and the loyalty which he possessed so abundantly and which contributed so much to his charm, must have had their origin in these early surroundings.

He graduated from the Johns Hopkins Medical School in 1912 after four years of study, during which he was considered a good student with a capacity for thoroughness and industry. His class standing was such that he obtained a surgical internship at the Johns Hopkins Hospitals with Dr. William S. Halsted. This was the beginning of an association with Doctor

Halsted which lasted for ten years, and which left an indelible impression on Reid's life. From "The Professor," as Doctor Halsted was called by his staff, he learned the gentle, meticulous surgical technic which he championed, obtained an interest in the principles of wound healing which he always maintained, developed a fascination for studying the surgery of blood vessels



and acquired a remarkable clinical judgment and diagnostic ability based on a searching inquiry into the history, a painstaking physical examination and an unusual alertness to salient facts and findings. His relationship with Doctor Halsted as I saw it from 1919 to 1922 was comparable to that between father and youngest son—affection and vicarious pride in achievement on the one side and admiration and devotion on the other.

Following his internship in Surgery Doctor Reid spent a year in Pathology with Doctor Bloodgood, following which he returned to the Surgical Department. He was assistant resident in Surgery until 1918 when he became resident surgeon, a post he held for three years. In 1922 he went to Cincinnati, with Dr. George J. Heuer, as associate Professor of

Surgey at the University of Cincinnati The Surgical Department had recently been reorganized and Doctor Reid played an important part in developing it into one of the well recognized surgical centers in America He acted as visiting Professor of Surgery to the Peking Union Medical College of China in 1925 During his stay there he made many friends among the Chinese, from whom he continued to receive letters and tokens of affection for many years In 1931, he became Professor of Surgery at the University of Cincinnati and held this position until his death Under his progressive regime his department, reflecting his surgical enterprise, expanded steadily by contributing to the literature, by training young surgeons and by constantly elevating the standards of surgical care provided the many patients entrusted to it As Professor of Surgery he assumed his responsibilities to the University of Cincinnati in a most serious manner and spent considerable time and effort in interesting the community in its Medical School It was largely through his interest and effort that funds were obtained to remodel the Cincinnati General Hospital in accordance with its growing needs He also secured funds with which he increased the staff of his, and other departments, in the Medical School

To the Surgical Profession, Doctor Reid was best known for his contributions to the surgery of great blood vessels and of the thyroid gland He was one of the notable figures in American Surgery and was a member of many important surgical societies among which were the American Surgical Association, Clinical Society of Surgery, Southern Surgical Association, Society of University Surgeons, The American College of Surgeons, and the Central Surgical Association He always contributed his share to these organizations by serving on various committees and by presenting papers at the meetings To his students and to the members of his staff he will be remembered as an understanding, approachable, courteous gentleman who never appeared too busy to hear their troubles and joys He had a real interest in their careers and always found time to discuss their future with them and to give them sound advice He had infinite patience and won his point more often by persuasion than by force Having made his decisions carefully he was not easily dissuaded from them He was an impressive teacher who excelled more in instructing smaller groups on ward rounds than in holding large and formal clinics He understood the Halsted principles of surgery as well or better than any of Doctor Halsted's protégés, and taught them well to his staff and students, by example, by his lectures, and by his writings He spread the Halsted philosophy of careful attention to those details of surgery so necessary to ensure kindly wound healing and an uncomplicated convalescence His house staff loved him and were to him a source of never-ending interest and delight

With his kindness, his unselfness and his winning personality he quickly assumed an important position in the community He was extremely interested in civic affairs and by his own efforts, and often with the support of the city's most influential citizens he did much to make Cincinnati a better place in which

to live. His patients came from every walk of life and to each of them he gave of himself unsparingly. He was noted for his kindness to his patients, for his genuine concern for their comfort and for his attention to even the smallest detail of their treatment. The city's wide concern over his illness and the evidences of affection shown at his funeral services bear witness to the esteem in which he was held.

Mont Reid had a well-rounded life, accomplished more than is permitted to many, and with his death there passes from the scene a lovable character, a superb surgeon and a most loyal friend.

B. N. CARTER, M.D.

EDWARD JOSEPH ILL

1854-1942

EDWARD JOSEPH ILL, physician, surgeon, gynecologist, obstetrician, and one of New Jersey's great citizens, was born in Newark, May 23, 1854, and died on June 8, 1942, at the venerable age of 88 years. He was the son of



Dr. Fridolin and Julia Ill, who migrated to this country in 1850, being early political revolutionists, who fled from Germany.

His early education was obtained in the public schools of Newark. In 1875 he was graduated from the College of Physicians and Surgeons at Columbia University and immediately went abroad to continue his studies for a period of two more years in Vienna, Freiburg and Strassburg.

Upon completion of his studies abroad, he returned to enter practice with his father in Newark. He went into general practice. The small laboratory which he possessed was equipped only with a microscope, and his library contained 20 standard reference books. In November of 1877, having been in practice for only a year, he had an opportunity to remove a shawl pin from the right bronchus of a child. He immediately published this experience in the New Jersey Medical Record.

His first appointment to a hospital staff was to the German Hospital in Newark. Soon he became interested in gynecology, and one of his early reports was of 37 operative cases on the cervix, for lacerations which he reported before the New Jersey State Medical Society. An early contribution, and one of importance, was a report of a case of resection of a gangrenous sigmoid, with recovery.

Doctor Ill's interests were varied, even at this early age. In 1879 he was made the School Commissioner of the City of Newark, and rendered a great service to his community by being instrumental in introducing a law which prohibited children, who had been ill with scarlet fever, from returning to school until a doctor's certificate certifying that contagion was no longer present, had been obtained. Great opposition to this law was encountered, for the laity felt that it was simply another way for doctors to collect a fee. Doctor Ill obtained a promise from all the doctors in his community that no fee would be charged in issuing such a certificate. He was one of the founders and the first president of the Academy of Medicine of Northern New Jersey. He contributed largely to the library, by giving numerous rare medical volumes. For a period of 32 years he was on the Board of Directors of the Prudential Insurance Company, and was later made Chairman of the Finance Committee.

At the age of 76, he took a most active part in the battle waged at this time, to prevent the use of impure ergot in maternity cases. He was an early advocate that intervention by the Federal authorities should be instituted to ban the use of impure and adulterated drugs of all kinds, and spent much time in Washington for this purpose.

Doctor Ill was a strong character, and though frail physically, possessed a tremendous vitality. He was open-minded, kindly, at all times exceedingly forceful, and always an understanding physician.

In 1900 he was made a member of the Southern Surgical Association. He attended its meetings frequently, and contributed to its discussions. He was a member of numerous surgical and medical societies of his own State and of the nation. He contributed in abundance to the literature, principally on gynecologic subjects.

On the anniversary of his 85th birthday, the City of Newark, through the Academy of Medicine of Northern New Jersey, did him honor. This was an occasion, and distinguished men from many parts of the country came to honor him. He was greatly impressed by the ovation, and particularly by the delivery of the highly flattering addresses. When asked, after this

meeting for his impressions, he said—and this was very significant of his whole character “For all these honors that were given me, I have felt that I have only done my duty to my profession, my family and my patients”

HENRY CAVE, M D

HENRY DAWSON FURNISS,² M D , LLD

1878–1942

On January 25, 1942 Dr Henry Dawson Furniss died of a heart ailment at his home, 6 Henderson Place, New York, N Y



Doctor Furniss was born in Selma, Alabama, on March 25, 1878, the son of John Perkins and Elizabeth Matthews Dawson Furniss. He attended the University of Alabama from 1894 to 1896 and in 1928, received the honorary

degree of Doctor of Laws from that school. Doctor Furniss left the University of Alabama and attended the University of Virginia, where he was graduated in Medicine in 1899. He went to New York and took the examinations for internship at the New York Post-Graduate Hospital, and went on service in this hospital on October 1, 1899, for a two-year appointment. During this time he worked under eminent surgeons, including Dr. Robert T. Morris, a Senior Fellow of this Association, and the late Dr. Hermann Boldt, who also was a member.

Upon completion of this hospital appointment he went to Europe and attended clinics. Later he returned to Selma and practiced there several years. He gave up his practice in Selma and went to New York where he became associated with the Post-Graduate Hospital Medical School, to which institution he was appointed Instructor in Gynecology in 1904, Assistant Professor in 1910, and Professor in Gynecology in 1917 until 1927 and was Attending Gynecologist at the Hospital during that period. At the completion of this long term of service he resigned his professorship and became Consulting Gynecologist to the Post-Graduate Hospital. He held the following positions also: Consulting Gynecologist, St. Agnes Hospital, White Plains, N. Y., All Souls' Hospital, Morristown, N. J., Hackensack Hospital, Hackensack, N. J., Broad Street and Holy Name Hospital, Teaneck, N. J., and St. Luke's Hospital, Newburgh, N. Y., Consulting Cystoscopist, N. Y. Infirmary for Women and Children, Attending Surgeon, Fifth Avenue-Flower Hospital and Metropolitan Hospital, New York, being Professor of Gynecology and Attending Gynecologist to the former.

During World War I Doctor Furniss served in the United States Army Medical Corps with the rank of Captain, and at the end of the war in 1918 he was Chief Surgeon at Camp Hancock, N. J.

Doctor Furniss enjoyed a large private practice and was beloved by his patients. He took great interest in attending meetings of the various medical societies and associations of which he was a member, and always took an active part. He was possessed of an unusual mechanical ability which enabled him to devise various instruments and ingenious devices which were used by the profession. He is well known for the catheter and the intestinal clamp which bear his name, and was a genius for making little improvements on other instruments to suit his own needs.

In addition to gynecology he was greatly interested in female urology and contributed over fifty articles to the literature on these two subjects.

Doctor Furniss was a Diplomate of the American Board of Obstetrics and Gynecology, and a Fellow of the American College of Surgeons and New York Academy of Medicine, a member of the American Medical Association, American Urological Society, a Life Fellow of the New York Obstetrical Society, and an Honorary Fellow of the American Association of Obstetricians, Gynecologists and Abdominal Surgeons. He was elected a member of the Southern Surgical Association in 1929 and was a constant attendant at most of the meetings. He always looked forward to the meetings of this

Association, and told many of us that he preferred attending these meetings to any other

He is survived by his wife, the former Ruth Kellogg Pine, whom he married in 1912, and three sons Henry Dawson Furniss, Jr., James Pine Furniss, and Warren Todd Furniss, and two grandsons, Henry Dawson Furniss 3rd and Peter Randall Furniss

Doctor Furniss was truly a Southern gentleman, soft-spoken, kind-hearted, and well liked by his intimates, and, as one of his close friends stated, he was almost too honest for his own good. At times his frankness may have been the source of some embarrassment to himself. Nevertheless, he was strongly admired for this very quality.

His untimely death at the age of 64 was a great shock to all of us and he will be greatly missed at the meetings of this Association.

JOSEPH E. J. KING, M.D.

ROBERT COALTER BRYAN

1873-1941

ROBERT COALTER BRYAN was born at "Brook Hill," Henrico County, Virginia, June 27, 1873, the second son of Joseph and Isobel Stewart Bryan.

He was educated at private schools in Richmond, he attended the University of Virginia, and later spent two years in the Engineering School at the University of Pennsylvania where he played an active part in college theatricals. In 1895 he entered the College of Physicians and Surgeons in New York City, and graduated with distinction, later going abroad for a year's residence study in Vienna. Returning to Richmond, Doctor Bryan began the practice of medicine, and shortly won recognition as one of the city's outstanding surgeons.

Doctor Bryan was Professor of Anatomy from 1904 to 1911 at the University College of Medicine, which was later merged with the Medical College of Virginia, and for some years was Professor of Genito-Urinary Surgery at the Medical College of Virginia, from which position he retired in 1932. Doctor Bryan served on the staffs at Stuart Circle and Memorial Hospitals in Richmond. He was a founder of Grace Hospital, Richmond, where for a number of years he was chief surgeon.

During the first World War Doctor Bryan served as a member of the Commission of the American Red Cross to Roumania and later, in France gave his valued services at the hospital at Jully.

In May, 1916 Doctor Bryan was commissioned a first lieutenant in the Medical Reserve Corps, U. S. A., and in March, 1917, was commissioned first lieutenant, Officers Reserve Corps, Army of the United States. On June 5, 1917, he received the commission of major in the medical section Officers Reserve Corps, United States Army.

He held membership in the Richmond Academy of Medicine, Medical Society of Virginia, American Medical Association, Southern Medical Association, American Association of Genito-Urinary Surgeons (President in 1935), Southern Surgical Association (Vice-President in 1928), Tri-State Medical Association of the Carolinas and Virginia (of which he was a former President), American Urological Association, and the International Society of Urology. He was a Fellow of the American College of Surgeons.



His countless acts of kindness, and his assistance to young physicians are known only to the recipients of his quiet covert generosity. Few men have been held in such high esteem by so many.

For the last six years of his life Doctor Bryan was a constant sufferer from arthritis, and on Christmas Eve, 1941, he died suddenly at his home in Richmond.

In October, 1914, Doctor Bryan married Miss Grace Hamilton, of Oak Hill, Maryland, who survives him, with two sons, Jonathan Bryan, III, and Robert Carter Bryan.

J. SHELTON HORSLEY, M.D.

ROSS ARLINGTON WOOLSEY

1877-1942

Ross Arlington Woolsey was born at Knoxville, Illinois, December 23, 1877. His elementary and premedical education was completed in Galesburg, Illinois, and he entered Marion-Sims-Beaumont Medical College in 1900



graduating in 1904, after it became the Medical Department of St. Louis University. Two years internship at Frisco Hospital, Springfield, Mo., followed, and he returned to St. Louis, in 1906, entered the St. Louis Frisco Hospital and faithfully served the Frisco Employees Hospital Association as House Surgeon, Surgeon-in-charge and Chief Surgeon, until his accidental death on February 23, 1942, at St. Louis.

On April 17, 1912, he married Mary Ricaud Beck, two children, Anne Beck (Mrs. Eugene L. Pearce, Jr.) and Ross A. Jr. (Lt. Field Artillery U. S. A.), blessed the union.

Doctor Woolsey became a member and an active participant in the meetings of the following professional organizations

American College of Surgeons
American Board of Surgery
St Louis Medical Society
Missouri State Medical Association (Pres 1937)
American Medical Association
St Louis Clinics (Pres 1926-29)
St Louis Surgical Society
Mississippi Valley Medical Association
American Association for the Surgery of Trauma
American Society for the Control of Cancer
Western Surgical Association
Southern Surgical Association
Southern Medical Association
American Association of Railway Surgeons
American Association of Chief Surgeons

Enjoying an extremely wide circle of friends, Ross Woolsey led a very active social and professional life, and fully relished every day of it. He possessed the rare ability to hew to the line in the interests of those whom he served, meanwhile retaining the loyalty, respect and affection of the personnel involved.

Although tireless at his work, he firmly believed in adequate recreation for the busy doctor and sought his relaxation in golf, and the woods and streams of the Ozarks and no better sportsman ever wet a line.

Beloved by his host of friends, he left an indelible imprint on the hearts of his close companions. His family life was a model of serenity and happiness, his wife and children his most cherished possessions, around whom all other activities and ambitions centered. To all who knew and loved Ross Woolsey, his passing leaves only kindly memories of a loyal friend, an ever welcome companion, a staunch character and a sound surgeon, whose destiny had been fully compensated by accomplishment.

F W BAILEY, M D

THOMAS PINCKNEY WARING

1867-1943

Dr Thomas P Waring, fellow of the Southern Surgical Association since 1911, died at his home in Savannah, Georgia January 8, 1943, after a short illness. Coming from a family of medical men, Doctor Waring was born in Savannah in 1867, the son of Dr James Johnston Waring and Mary Alston Waring. He lived in only two locations during his entire life, the house where he was born and the house where he died. After attending the Graylock Institute at Williamstown, Mass., he graduated A B from Yale College in 1889 and received the M D degree from the College of Physicians

and Surgeons in New York, in 1892, where he stood first in his class. Following an internship at Bellevue, he travelled and studied abroad, visiting Scotland, Germany and Austria, and then began a half-century of practice in his home town of Savannah.



Doctor Waring, a Fellow of the American College of Surgeons, became one of the leading surgeons of Savannah and the state of Georgia. At first he served in the capacity of a junior partner with the late Dr. Raymond B. Harris, as was the custom in those days. While associated with Doctor Harris, Doctor Waring became head of the Telfair Hospital. Then, in 1910, Dr. John W. Daniel invited him to become coowner of the Oglethorpe Sanatorium. He accepted and built a surgical unit and nurses' home on the land, and at the time of his death he was sole owner. On more than one occasion he was president of the Georgia Medical Society of Savannah, one of the oldest local medical organizations in the country, corresponding to the county-medical

society in other places. Due probably to his modest, retiring disposition, Doctor Waring was not a frequent speaker at the meetings of the Southern Surgical Association, and added but few articles to surgical literature. However, his professional knowledge and surgical ability were well recognized, and he enjoyed one of the most extensive and select practices in his part of the state.

He was a vigorous person, pursuing widely varied activities, ever young in spirit and in his response to life's demands and fields of endeavor. He had a host of friends throughout his native town, and held a warm place in the hearts of his medical confreres. The description "scholar and gentleman" fitted him well. He was a student and inveterate reader, and always kept abreast of the times, in medicine and other activities. Doctor Waring was a charter member of the Society of Colonial Wars in Georgia, and served as its Governor before becoming deputy governor general. He was an active member of several social organizations.

In 1902 he married Miss Martha Gallaudet Backus, who passed away shortly after the death of her husband. Two children survive, one son, Dr. Thomas Pinckney Waring, Jr., and one daughter, Miss Frederick M. Stetson. The present T. P. Waring represents the fourth generation of practicing physicians in direct line in the family. The mayor of Savannah paid the following tribute to Doctor Waring:

"In the death of Dr. T. P. Waring Savannah lost not only a physician of outstanding ability, one who was recognized by the medical profession here and throughout the state and elsewhere as a leading surgeon and practitioner, but has likewise lost a citizen who loved Savannah, whose interests were all centered in Savannah, and who was devoted to everything that promoted the welfare of the city of his birth and life. The passing of a man like Doctor Waring is a distinct loss to the community. He represented the type of citizenship that exemplified the finest attributes of character. He will be long remembered, not only in his profession and among those whom he served in a professional way, but likewise by a host of Savannahians who knew and appreciated his sterling worth to our city."

FRANK K. BOLAND, M.D.

HERMANN JOHANNES BOLDT

1856-1943

Hermann Johannes Boldt, son of Hermann and Amalie (Krüger) Boldt, was born in Germany on June 24, 1856, at his father's estate, Neuentempel near Berlin. He came to New York with his parents in 1865, went through the public and high schools, received private instruction in languages and mathematics, and devoted his evenings to the study of pharmacy, passing the examination in the latter study in 1877. He commenced the study of medicine in 1875, and was graduated from the Medical Department of New York University in 1879. After graduation he practiced medicine in New York and passed all his professional life in that city. For many years he spent the summer months in the hospitals of Europe. On August 29, 1891, he married

Miss Hedwig Kruger in Berlin. They had one son, Hermann Johannes Boldt, Jr., who was killed in 1918, in the first World War.

Doctor Boldt was Professor of Gynecology at the Post-Graduate Medical School from 1891 to 1917, then Emeritus Professor. He was one of the founders of the German Poliklinik and of St. Mark's Hospital. He was



Gynecologist to both of these, and Consulting Gynecologist to the New York Post-Graduate Hospital, Stuyvesant, Polyclinic, St. Vincent's, Beth Israel and Union Hospitals.

He was one of the founders, formerly a member of the board of governors, and Fellow of the American College of Surgeons, member of the Southern Surgical Association, American Gynecological Society, New York Obstetrical Society, New York Pathological Society, American Medical Association, Gynaecological Society of Great Britain, New York Academy of Medicine, Royal Society of Medicine, Association of Military Surgeons of the United States, and various local societies.

He was an investigator into the physiologic action of cocaine and a prolific writer on all aspects of gynecology. Besides many articles in medical journals, he wrote the chapters on "Benign and Malignant Neoplasms of the Vulva and Vagina and of the Uterus" in the textbook Clinical Gynaecology by

Emminent American Teachers, published by J B Lippincott Co., in 1895 He was also a contributor to the Enzyklopadie der Geburtshilfe und Gynakologie, published in Leipzig in 1900 He invented an operating table for abdominal surgery which won a medal at the Paris Exposition in 1900, and also a modern examining table for office use

Doctor Boldt had retired from practice and spent his winters at St Petersburg, Florida, where he died on January 12, 1943

RAYMOND P SULLIVAN, M D

CHARLES WATTS FLYNN JR

1884-1943

Doctor Flynn a Senior Fellow of the Southern Surgical Association, died at his home in Dallas on August 13, 1943 It is particularly appropriate that this memorial should appear in the Transactions of this organization as the Southern Surgical Association was the professional organization most



beloved by him Beginning with his election to Fellowship in 1923, he attended practically all its meetings, occupied a chair on the front row of the auditorium with regularity, and always brought back to his students in the Medical School a detailed account of the surgical advances annually presented at its meetings He was honored by election to the Vice-Presidency of the organization in 1937

Charles Watts Flynn was born at Lakeland La., and received his preliminary education at the Sanders Preparatory School, Baton Rouge, La., and the Louisiana State University, where he received the degree of Bachelor of Science in 1905 In June, 1911, he received his Medical Degree from the Medical Department of the University of Pennsylvania After serving an internship in Pittsburgh, Pa. he located in Dallas in 1912 and engaged in the practice of general surgery until his death

He was happily married to Miss Mary Watts Knight daughter of a distinguished, pioneer lawyer, R E L Knight, in 1917

He was associated with Baylor University College of Medicine immediately on coming to Dallas and later became Professor of Surgery and Chief Surgeon of Baylor Hospital. He was an excellent teacher, genial, kindly and meticulous in his relation to students and professional conferees. Illness forced him to retire from active duties before his death and he became Honorary Professor of Surgery at the Southwestern Medical Foundation Medical School now located in Dallas and held this position at the time of his demise.

Doctor Flynn was a Fellow of the American College of Surgeons, Fellow and former President of the Texas Surgical Society, and a member of numerous social and professional organizations.

CURTICE ROSSLER, M D

ARCHIBALD JOHNSTON BUIST

1872-1943

On September 12, 1943 occurred the death of Dr Archibald Johnston Buist, of Charleston, South Carolina. Doctor Buist was the son of Dr John Somers and Margaret Sinclair (Johnston) Buist, and was born in Charleston February 7, 1872. His preliminary education was obtained in the Charleston Schools, Lawrenceville Academy (New Jersey) and Princeton University, graduating from this institution in 1893 with the B A degree. He then returned to his native city and entered the Medical College of the State of South Carolina and graduated in 1896 with first honors. After serving as intern in the Charleston City Hospital for a year he went to New York and took post-graduate work in the New York Lying-in Hospital, and other New York Hospitals.

As a student in the Medical College Doctor Buist began his long teaching career, being an assistant in the Department of Pathology and Bacteriology from 1895 to 1899, assistant in General Surgery from 1895 to 1899, Lecturer in Minor Surgery and Bandaging from 1899 to 1904. Professor of General Surgery from 1904 to 1910. Professor of Abdominal Surgery and Gynecology 1911-1912 and from 1912 until 1939 he occupied the chair of Professor of Gynecology. In 1939 he tendered his resignation to the Board of Trustees and was elected Emeritus Professor of Gynecology. Doctor Buist was singularly well equipped to teach, in that he never used notes in his classes and he illustrated the points of whatever subject was under discussion by descriptions of personal experiences having a bearing on the matter. His students respected him for his broad knowledge and his willingness to discuss with them any problems they might bring to him.

Doctor Buist was a man who enjoyed being in the company of his friends on fishing trips, for he was a keen fisherman. His genial nature and enjoyment of life was a delight to his friends and it was on such a fishing party that he died as he had lived in the company of close friends.

Many honors came to Doctor Buist. During World War I he served as

chairman of the Third District Advisory Board for South Carolina, he was chairman of the local chapter of the American Red Cross, President of the Board of Trustees of the Charleston Museum, he was a member of the American Board of Surgery, the Southern Surgical Association (1913), the American and Southern Medical Associations, and a past President of the Medical Society of South Carolina



Doctor Buist was twice married in 1899 he married Miss Alice Stock Mitchell, by whom he had a son, Dr Archibald Johnston Buist, who is at present serving in the United States Navy After the death of his wife he married Mrs Elizabeth Rollei Gestefeld, who survives him

No higher praise can be given a man than to be able to say, at the end of his life, that "Here was a man who loved humanity and spent nearly half a century in service to humanity's common need "

R S CATHCART, M D

GRANVILLE S HANES

1864-1943

Doctor Hanes was born at Haysville, Mason County, Tennessee, in 1864, and obtained his education in the common schools of his home State. Early in his life he made the acquaintance of a physician in Indiana who became so impressed with his energy that he paid his tuition in the Medical College of Indiana. At the time of this friend's death he was stranded in Indianapolis and went to Mr. W. D. Allison to apply for a position in order to earn enough money to complete his medical education.



Times were hard and he was informed that nothing could be offered. He insisted that he had no place to sleep, and at the suggestion of one of the clerks, Mr. Allison let him sleep on an operating table in the store. He made himself so useful that he was put on the road and proved the best salesman the firm ever had.

Some years later he canvassed the Louisville profession and met Dr. Joseph M. Mathews who induced him to enter the Hospital College of Medicine, where he made many valuable friends, including Dr. Lewis S. McMurtrey and obtained his Doctorate in Medicine there in 1900. Soon he became clinical assistant to Doctor Mathews and his associate in private practice, learning much from the wise counsel of his friend. A Nedifik sofa in their office was used for the knee-chest position in examination of the rectal cases and Doctor Hanes found that he could look directly down into the bowel and that it was

fully distended with air, permitting a complete view of the tube easily when thus readily filled with air. This led Hanes to devise the table which he used throughout his life and still retains his name.

Doctor Hanes was a man with an inquiring mind, and he had what Wen Mitchell called a fermenting brain, full of ideas, many of which were of therapeutic value. Often his ideas caused debate. Rarely this was caustic, especially among some of his envious competitors. He had a very pleasing personality, but was rather fixed in debate, and a good raconteur.

Doctor Hanes was Professor of Diseases of the Rectum, University of Louisville Medical School, Fellow of the American College of Surgeons, Fellow of the Southern Surgical Association, President of the Proctological Society, and a Major in the Medical Corps of the United States Army.

At a meeting of the Kentucky and Tennessee section of the American College of Surgeons in the Brown Hotel the Chairman of the meeting turned that body over to Hanes, Haggard and Hendon, all master entertainers, and the pleasure of the occasion was unbounded. What a pity that no record persists of their remarks. Doctor Hanes gave great care to his patients, and his devotion was splendid. In return, he held their appreciation and regard until the end of his life which was tragic. But true to form he passed out as he lived—dramatically. Those who knew him best loved him most.

J GARLAND SHERRILL, M D

FRANK L BARNES

1872-1943

On October 2, 1943, Dr. Frank L. Barnes died at his home, 10 Chelsea Place, Houston, Texas, of coronary occlusion.

Doctor Barnes was born September 26, 1872, in Trinity, Texas. He received his academic education at Hill's College, Waco, Texas, while his Medical education was obtained at the College of Physicians and Surgeons, Baltimore, Maryland, in 1896. While in medical college he served as professor in anatomy. Following his graduation he served an internship in Mercy Hospital, Baltimore, Maryland.

He was a member of the American Medical Association, Harris County Medical Society, South Texas Postgraduate Medical Assembly, Fellow of the American College of Surgeons, Founder Member of the Texas Surgical Society, Founder Member of the American Board of Surgeons and a Fellow of the Southern Surgical Association. During the Spanish-American War he served as an assistant surgeon to the Army, being stationed at Galveston, Texas.

Doctor Barnes was one of the few remaining pioneer Texas surgeons, having practiced at Trinity, Texas, on horseback, with saddle-bags, prescribing and dispensing his own medicines. He had an extensive surgical practice, beginning his surgery at the time it was done in the home or in his office and then sending the patient home in a wagon.

In 1908, he built a hospital in Trinity, Texas, where he did an extensive surgical practice until 1915 when he moved to Houston, where he remained until his death

Doctor Barnes married Miss Alice Johnson of Trinity, Texas, June 8, 1898, and they had two daughters, Miss Aubrey Calvin and Mrs William M McKinney, of Houston and two sons, Edward F Barnes, now serving in the Navy, and Dr Paxton Barnes of Houston, Texas



Doctor Barnes occupied a very prominent position in Surgery in Texas, and was known for his great surgical judgment. He was of a retiring disposition but never failed to take a positive stand on the right side of every question concerning Medical Ethics. His loss will be felt not only in Houston but in the entire State of Texas.

Besides his immediate family he was survived by two brothers, William and Jesse Barnes, of Trinity, and three sisters, Misses Hattie, Mattie and Marv Barnes, all of Trinity.

CHARLES C GREEN, M D

SURGICAL LESIONS OF THE FACIAL NERVE
WITH COMMENTS ON ITS ANATOMY

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SURGICAL LESIONS of the facial nerve are nearly always due to trauma, but there is a smaller group of patients who require operation upon the nerve because of intractable facial spasm. The main purpose of treatment in both of these surgical affections of the nerve is to correct a conspicuous facial deformity. While facial paralysis and intractable facial spasm both produce embarrassing facial deformities, the spasm, being a deformity in motion, is the more conspicuous of the two.

Trauma of the nerve trunk almost invariably causes paralysis involving the entire facial musculature. In a paper before this Association in 1939, an effort was made by the writer to analyze the facial deformity due to paralysis of the trunk of the nerve. The components of the deformity mentioned at that time will be emphasized on the basis of further observations.

The massive facial deformity resulting from paralysis of the trunk of the nerve is not uniformly distributed. It is less obvious in the upper facial area and reaches its maximum about the mouth. The most conspicuous and embarrassing feature of the deformity of unilateral facial paralysis arises from displacement of the mouth by unopposed contraction of the muscles of the healthy side, whereas the alteration of facial appearance caused by paralysis of other muscle groups, such as those of the cheek, eyelids, and brow, is not exaggerated by activity of the muscles on the normal side. In long continued facial paralysis there is inevitable sagging of the angle of the mouth, causing the lips to assume an oblique direction. The result is a repulsive deformity (Fig 1). Paralysis of the lower muscle groups supplied principally by the mandibular division permits deviation of the mouth to the opposite side, causing a sudden increase in the deformity when the healthy side of the face goes into action. The musculature in the upper half of the face is more or less fixed to its own side and is comparatively unaffected by muscle action of the opposite side. Not only is the deformity of facial paralysis greater about the lower face

* Read by title before the Southern Surgical Association, December 7-9, 1943, New Orleans, La

and mouth, but the permanent residuals of such paralysis after reinnervation of the previously paralyzed muscles are most noticeable in this area regardless of the type of surgical procedure employed for restoration of function. Balance of the mouth is maintained principally by action of the mandibular branch which should be regarded as the most important single branch of the nerve in the preservation of facial symmetry.

Protection of the facial nerve from injury during certain operations for lesions in close proximity to the nerve may be more difficult and a matter of more concern than the surgical treatment of the nerve, itself, for paralysis. Injury to the nerve during such operations, with resulting paralysis, however unavoidable, causes a serious deformity to the patient and must



Treatment of Facial Paralysis With Fascial Strips

FIG 1—(A) Characteristic appearance of patient with facial paralysis of long standing. Paralysis followed complete removal of a left acoustic neurinoma. The sagging of the face and drooping of the angle of the mouth are the conspicuous features of the deformity. The facial muscles had lost galvanic response and anastomosis was not indicated. The patient's serious condition following operation precluded early anastomosis of the nerve, which is desirable within a few weeks after removal of the tumor.

(B) Appearance of patient after support of the paralyzed side by subcutaneous fascial strips anchoring the muscles about the mouth to the temporal muscle, after the method of Brown. Small fascial strips also were used to support the lower eyelid.

be considered a severe penalty for the patient to pay for a surgical procedure. Malignant lesions lying in the course of the nerve, such as tumors of the parotid, may require sacrifice of the nerve to eradicate the lesion, but even in such cases the patient should be told in advance of the likelihood of facial paralysis with careful explanations as to what such paralysis really means. The protection of the facial nerve in the removal of malignant conditions which have not actually invaded the nerve requires a thorough knowledge of the nerve anatomy and its branches and the use of a technic which exposes the nerve adequately so that removal of the lesion may be accomplished with the nerve clearly visualized.

LESIONS OF THE FACIAL NERVE

The facial nerve may be jeopardized in varying degrees by the following operations. Complete removal of acoustic neurinomas, section of the auditory nerve for Menière's disease or intermediate nerve for certain paroxysmal neuralgias, temporal or suboccipital section of the root of the gasserian ganglion for tic douloureux, mastoidectomy, and removal of extracranial tumors, such as those of the parotid.

Operation may be required to relieve paralysis resulting from injury to any part of the nerve trunk or its main peripheral branches. The branches of the nerve are frequently divided by stab wounds and spicules of glass in the region of the parotid. In such cases the mandibular branch usually escapes injury, being protected by the ramus of the jaw (Fig. 2).



FIG. 2—(A) Patient with bilateral paralysis of the sixth and seventh nerves from fracture of the base of the skull. The right facial and both sixth nerves recovered in about six months but there was no improvement in the left facial at the end of 12 months. A faciohypoglossal anastomosis was then performed on the left side.

(B) Appearance of patient one year after faciohypoglossal anastomosis on the left.

(C) Patient shown in (A) and (B), two and one half years after anastomosis. Mass movements in this case were not pronounced.

Intracranial injuries of the nerve nearly always result from complete removal of an acoustic neurinoma. In recent years in my clinic this has been the cause of a large majority of cases of division of the trunk, injury from mastoid operations having become much less frequent due to more expert surgery. Destruction of the facial nerve intracranially has been generally accepted in this country as an almost inevitable penalty the patient must pay for complete removal of the average size acoustic neurinoma, although some of the smaller tumors may be removed without serious damage to the nerve. In the writer's experience, one of the largest acoustic neurinomas in the series was completely removed without severing the nerve, but we have not been able to duplicate this rather fortunate experience. If damage to the facial nerve could be prevented in the formidable operation for complete removal of these tumors, the procedure would represent one of the most brilliant technical achievements. Perhaps this may yet be accomplished and Olvecrona's success in removing these tumors completely without dividing the facial nerve should certainly stimulate greater efforts by other surgeons toward protection of the nerve in this important operation.

Direct injury to the facial nerve in section of the auditory for Ménière's disease can nearly always be avoided if one has a good knowledge of the local anatomy. There may be a delayed and temporary paralysis following operation, probably due to edema. Division of the intermediate nerve without injury to the facial is more difficult, but the problem here is by no means so complicated as that involving large acoustic neurinomas. Furlow has reported a very interesting case of section of the intermediate nerve for intractable neuralgia without damage to the facial nerve.

The facial nerve is temporarily paralyzed in a small percentage of cases in temporal section of the sensory root of the gasserian ganglion for tic douloureux. There is rather general agreement at the present time that the cause of this paralysis is traction on the superficial petrosal nerve which leaves the facial from the geniculate ganglion. Such traction causes injury and edema of the facial with resulting paralysis for some weeks or months. In elevating the temporal dura for exposure of the sensory root, the superficial petrosal should be avoided, and if this is impossible it should be sectioned to prevent the possibility of traction on it.

We have adopted a conservative attitude toward facial paralysis following mastoid operations and have allowed at least six months for signs of spontaneous recovery unless the otologist were positive the nerve had been severely damaged. We have also adopted a conservative attitude in the treatment of facial paralysis following fracture of the base of the skull in view of the large percentage of cases of spontaneous recovery (Fig 3).

The removal of extracranial tumors along the course of the nerve, particularly those that lie deep in the digastric fossa, may seriously menace the nerve. In these tumors, as in other large tumors about the parotid, we have followed a plan of exposing the branches of the nerve distal to the parotid and tracing them backward to the pes anserinus, then exposing the trunk before attacking the tumor, itself. Damage to the nerve in the extirpation of these tumors, in the writer's experience, is most likely to occur to the mandibular branch, and we believe it is most important to isolate this branch at a point where the facial artery crosses the mandible and trace it backward to the trunk before the tumor is removed.

The type of surgical treatment for the relief of facial paralysis obviously will depend upon the location of the injury. When the nerve is divided intracranially, as in the complete removal of acoustic neurinomas, reinnervation of the facial muscles can be accomplished in only one way, that is, by the substitution of a healthy motor cranial nerve for the proximal portion of the facial. The nerve selected for the purpose of anastomosis usually has been either the hypoglossal or the spinal accessory, depending on the choice of the individual operator. In the selection of a nerve for anastomosis with the facial, one must give consideration not only to the functional results expected from the anastomosis, but to the disability resulting from sacrifice of the nerve to be used to replace the facial. In nearly all cases we have utilized the hypoglossal for fusion with the paralyzed facial,

LESIONS OF THE FACIAL NERVE

not only because of the functional similarity of the two nerves, but because the sacrifice of the hypoglossal nerve in such cases has produced no appreciable loss of important function. Careful voice studies before and after operation have shown no change in voice which could be attributed to the loss of the hypoglossal nerve. We have seen no case in which disturbance of deglutition was more than a temporary complaint. The spinal accessory nerve has been



FIG 3—(A) Division of the upper branch of the right facial nerve by a fragment of glass. The uninjured mandibular branch of the facial maintains balance of the face.
(B) Sketch shows location of the lesion. This is a common site of injury to the nerve. The mandibular branch generally escapes, being protected by the ramus of the jaw.
(C) Appearance of patient four years after suture of the upper branch. The wound was infected on admission to the hospital and suture was delayed for several weeks. The patient's facial appearance is normal, the corrugator muscles recovered, but there was no return of frontalis function.
(D) Patient, shown in (A), (B) and (C) is able to close the eyes without mass movements.

used in only a few cases and then because of some special objection to dividing the hypoglossal. Further observations on injury to the spinal accessory nerve have confirmed earlier impressions that section of this nerve may constitute a disability of some importance, but varying in severity in individual cases.

Spinal accessory paralysis has been studied recently with a great deal of thoroughness by Major Barnes Woodhall at the Ashford General Hospital. Major Woodhall states in a recent communication that "section of the spinal accessory nerve is certainly a disabling injury in military service" and that "the disability was not compatible with full military duty."

Facial anastomosis with either the hypoglossal or spinal accessory will restore motion to the paralyzed muscles, but there are mass movements of the face which is likewise true after suture or graft of any part of the nerve trunk. The results of anastomosis are also marred to some extent by associated movements which vary considerably in individual patients. In loquacious patients and those in which the tongue is brought into more active use in chewing and swallowing the associated movements may be very much exaggerated. The results of anastomosis might be improved by careful individualization of patients in the selection between the hypoglossal and the spinal accessory, using the latter for the vivacious type and the hypoglossal for those who use the tongue less freely.

A careful appraisal of the results of anastomosis of the facial with another motor cranial nerve shows that while there is great improvement in the facial appearance, normal facial activity is never restored. In repose, the patient's appearance is practically normal, there being no atrophy of the facial muscles, no asymmetry, and no sagging of the lower face. However, emotional expression never returns to the paralyzed side although the patient by deliberate effort may acquire a poor imitation of normal facial expression. Under the stimulus of emotion the normal side moves much more rapidly and spontaneously so that the mouth is drawn to the healthy side. Restoration of function of the frontalis muscle has not been observed by the writer after anastomosis except in one case, and in this instance the hypoglossal was used. I know of no satisfactory explanation for the failure of this muscle to recover movement after severe disease or injury of the nerve trunk. So far we have seen no return of platysma function following either suture or anastomosis of the facial nerve.

Injury of the nerve trunk in the facial canal, usually produced by operation upon the mastoid, has been repaired by short nerve grafts according to the method of Ballance and Duel. The most difficult part of this operation is the exposure of the facial canal and segments of the nerve in the diseased mastoid. To do this expertly requires special training in mastoid technic. The application of the nerve graft in such cases after exposure of the injured facial nerve is a relatively simple procedure.

Suture or graft of the nerve when practicable is preferred to any form of anastomosis, not because of better functional results, but because associated movements do not develop nor does the operation require the sacrifice of any other nerve. Insofar as restoration of facial movement and symmetry are concerned, the anastomosis is as effective as suture or graft of the trunk.

Repair of the facial trunk when it is severed extracranially by a stab wound is not difficult if it is done at the time the wound receives primary

LESIONS OF THE FACIAL NERVE



FIG 4—(A and B) Division of the upper and middle branches of the facial nerve by glass. Balance of the mouth is retained in repose but there is marked asymmetry on attempts to show the teeth. Patient is unable to close his eye. No effort had been made to suture the nerve at the time of primary treatment of the wound. (C and D) Patient shown in (A and B), eight months after suture of the upper and middle branches. The patient is able to close his eyes without mass movements and his mouth is balanced in smiling.

treatment The same is true of the important branches of the nerve If operation upon the nerve is delayed, formation of scar tissue makes the exposure and identification of the nerve or its branches much more difficult It is almost incredible that patients with an incised or penetrating wound in the region of the parotid, who are unable to close the eye or retract the angle of the mouth on the injured side, should have the skin wound sutured without any effort being made to expose and repair the nerve which is always divided (Fig 4) There is no other explanation for paralysis following immediately a stab wound along the course of any motor nerve, yet the patient is often told the nerve was traumatized and that spontaneous recovery may take place If the divided nerve is repaired at the time primary treatment is given the wound, its identification may be facilitated by the faradic electrode, whereas if there is a few days' delay, the distal segment of the nerve loses faradic response, and a more extensive dissection is required

The facial nerve may be injured and considerable loss of nerve substance result from gunshot wounds If the injury is located in the region of the pes anserina, repair of the nerve lesion is often possible only by grafts With wide destruction of the nerve branches, support of the face on the paralyzed side by fascial strips is the treatment indicated Injury of the nerve by gunshot in the region of the mastoid was occasionally seen in cases of the last war These injuries often cause extensive nerve destruction and reinnervation can be brought about only by anastomosis of the facial with another healthy motor cranial nerve

The technic of facial anastomosis and suture has been previously described in considerable detail and need not be discussed further In the repair of certain important peripheral branches of the nerve, technical difficulties may be encountered It may be necessary at times to suture the trunk of the nerve to two or more of its peripheral branches We have found this difficult in some cases particularly when the mandibular branch as well as those to the eye and cheek require approximation to the trunk To overcome the difficulty here presented, we have felt that a combination of suture and the plasma cuff of Mediwar and Young might be helpful in some of these cases In one instance of division of the trunk and its main branch during removal of a malignant tumor, and suture of the three main branches to the trunk being impossible, the two upper divisions were sutured to the trunk and an anastomosis of the spinal accessory with the mandibular branch was done The results were very satisfactory (Fig 5) In another case, suture of the branches to the eye and cheek was supplemented by a fascial strip to the mouth attached to the temporal muscle after Brown's method The results here were excellent (Fig 6) In all cases of suture we have used arterial silk for approximating the epineurium of the trunk and one carefully placed through-and-through suture for the small branches

The facial nerve has great capacity for regeneration under any but the most unfavorable conditions, but mass movements always occur following regeneration This is true whether there has been division of the trunk

LESIONS OF THE FACIAL NERVE

or of one or more of its branches, but in the latter case, the mass movements are confined to one group of muscles and are less conspicuous. In explanation of this, Howe, Tower and Duel, Ford and Woodhall, and others, have found that after section of the nerve or a severe degenerative lesion, regenerating



FIG 5—(A) Right facial paralysis following removal of a large malignant tumor of the parotid. The tumor extended deeply into the digastric fossa. The mandibular branch was involved in the tumor and a portion of this branch was sacrificed. The nerve trunk was much elongated. A portion of this was excised and the trunk was sutured to the upper and middle branches. It was impossible to make satisfactory suture of the mandibular branch to the trunk. Because of the importance of this branch it was anastomosed to the spinal accessory, the patient preferring the use of the latter nerve in the anastomosis. The case illustrates the difficulty of suturing the three main branches of the nerve to the trunk. This difficulty arises from the marked divergence of the mandibular from the other two main branches.

(B) Sketch of operation described in Figure 5 (A). When direct suture of the mandibular branch to the trunk is impossible, anastomosis of this branch with either the hypoglossal or spinal accessory is indicated.

(C), (D) and (E) Patient in Figure 5 (A), eight months after operation. The face is balanced in repose, there is ability to close the eye without conspicuous mass movements, and in smiling there is only slight deformity of the mouth.

fibers normally intended for one group of muscles may penetrate every muscle group within the facial domain. The result is that when the patient attempts to close his eye, the muscles about the mouth contract while efforts to move the lips are associated with contraction of the orbicularis oculi



A

B

Combination of Nerve Suture and Fascial Strips

FIG 6—(A) Injury of the left facial nerve. It was possible to suture the upper branches to the upper lip. Suture of the mandibular branch method were used to support the upper and lower lips. Recovery of orbicularis function has begun. The mouth is well balanced. (B) Photograph of patient shown in Figure 6 (A) three years after operation. He is able to close his eye, his face is balanced and there has been some recovery of muscle function of the upper lip. Symmetry of the lower face is well preserved by the fascial strips. Recovery of nerve supply after Brown's operation. Recovery of function after operation.

(B) Photograph of patient shown in Figure 6 (A) three years after operation. He is able to close his eye, his face is balanced and there has been some recovery of muscle function of the upper lip. Symmetry of the lower face is well preserved by the fascial strips.

(C) Patient is able to close eyes without mass movements



A

B

FIG 7—(A) Mass movements following recovery of function after division of the trunk of the facial nerve proximal to the parotid gland by a splinter of wood following direct nerve suture. Patient has restoration of all muscle groups except the frontalis. There are mass movements in attempts to close the eye. The case illustrates the inevitable development of mass movements following division of any portion of the facial trunk.

(B) Patient in Figure 7 (A) shown in repose

(Fig 7) This phenomenon of faulty regeneration partly explains the failure of any surgical procedure to restore normal movements or emotional expression to the face following severe lesions of the nerve trunk. Much has been said about reeducation of the patient after suture, graft or anastomosis of the facial nerve but it is difficult to understand how such reeducation could be of any value if the motor units of expression have been converted by faulty regeneration into units incapable of dissociated action of the type essential to normal facial expression. The importance of expression



FIG 8—(A) Severe intractable facial spasm. Section and suture of the upper branches of the nerve had been carried out twice, with relief of the spasm for about six months following each operation. In the meantime the spasm had spread to the lower facial muscles producing a very conspicuous and embarrassing deformity. The patient was greatly handicapped in her work as a teacher and requested the radical operation.

(B) Patient shown in Figure 8 (A) 11 months after division of the trunk of the facial nerve and anastomosis with the hypoglossal. The photograph shows the face well balanced and serene.

(C) The mouth is fairly well balanced in attempting to smile. The maximum recovery of function following anastomosis has not been reached and complete closure of the eye was not possible at the time the photograph was made but muscle tone about the eye is evident. Recovery of frontalis function is not expected and the penalty for this is slight lowering of the eyebrow.

of all facial activity since the residuals of the former paralysis are not noticeable when the face is in repose.

A brief reference only will be made to facial spasm. The subject was discussed before this Association in a previous paper. Inasmuch as the involuntary contraction of the orbicularis oculi muscle is the most disturbing feature of intractable facial spasm the nerve supply to this muscle is sectioned and resutured as a primary treatment. This operation may be compared to alcohol injection of a branch of the fifth nerve for the temporary relief of tic douloureux. The spasm usually returns in about six months, but in the meantime the patient not only has been relieved of spasm, but is in better position to know whether he wishes a more radical operation for permanent cure. We have never had a patient complain of facial paralysis produced in an effort to relieve facial spasm.

Severe facial spasm gives a patient such a grotesque appearance that he is willing to pay almost any penalty for its relief. If the spasm is confined

chiefly to the orbicularis oculi, and particularly if it recurs after previous section and suture of the nerve, this branch may be resectioned and the course of the proximal segment so changed as to prevent regeneration. However, if the spasm involves practically all the facial muscles, as is often the case, section of the nerve with faciohypoglossal anastomosis is recommended with full explanations to the patient as to this procedure in all its details (Fig 8)

Facial spasm is rarely bilateral, although we have seen a number of such

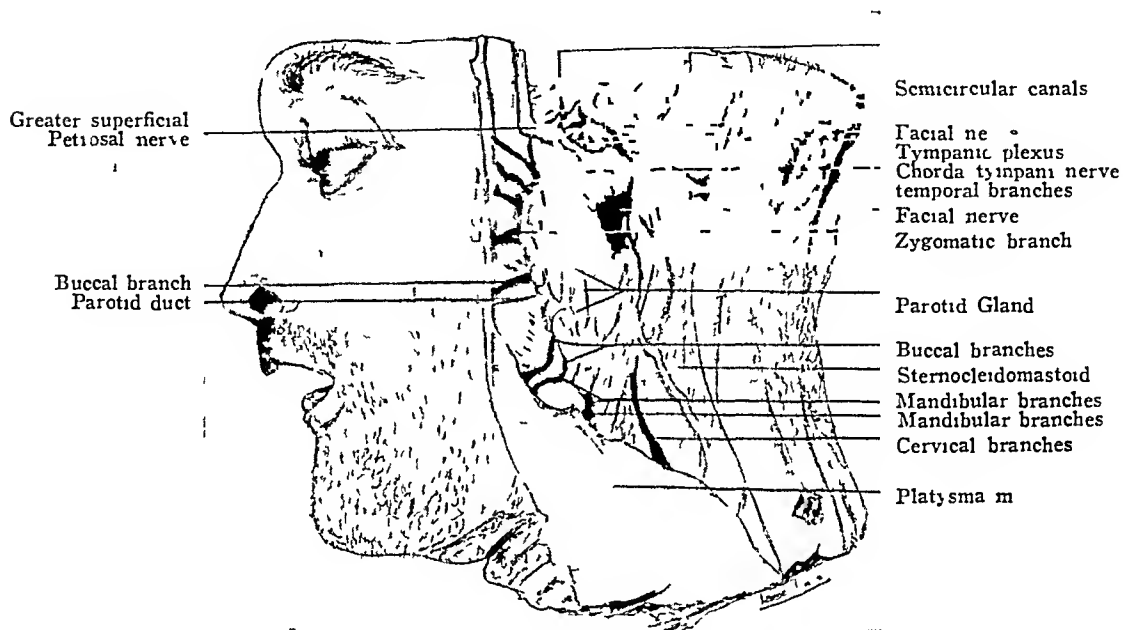


FIG 9—Drawing from actual dissection of the left facial nerve. The main branches of the nerve may be found after their emergence from the parotid gland. These branches may be easily identified at this point and traced back to the trunk or to the site of injury. In removal of certain parotid tumors, exposure of the nerve anterior to the gland provides protection to the nerve by keeping it in full view during removal of the tumor.

cases, due probably to encephalitis. Bilateral facial spasm produces not only a most conspicuous deformity, but also a marked disability. The patient may become helpless in traffic, unfit for driving a car, endangered in going down steps, and greatly handicapped in numerous ways by violent contraction which forcibly closes the eyes. In bilateral facial spasm practically the whole facial musculature, including the platysma, is involved. In the treatment of this condition we section the facial trunk and perform an anastomosis with the hypoglossal on the side most involved. The branches to the eye on the opposite side are sectioned and measures taken to prevent regeneration. Sagging of the lower lid after permanent paralysis of the orbicularis oculi can be improved by external canthoplasty or facial strip support.

In a number of dissections of the facial nerve prepared in Department of Anatomy of the Medical College of Virginia, we have been impressed

with the complexity and variation of the nerve pattern (Fig 9) ¹ In some patients the nerve begins to break into its main branches before the mandible is reached and there may be a second redistribution of the branches, resembling the pes anserina. The sketches of the facial nerve in text books give a very incomplete and inaccurate picture of the facial nerve as revealed in minute dissections (Fig 10) ¹ While there are three main groups of branches to supply the eye and forehead, the cheek, the lower lip and neck, there appears to be an intricate anastomosis of all these various branches so that fibers

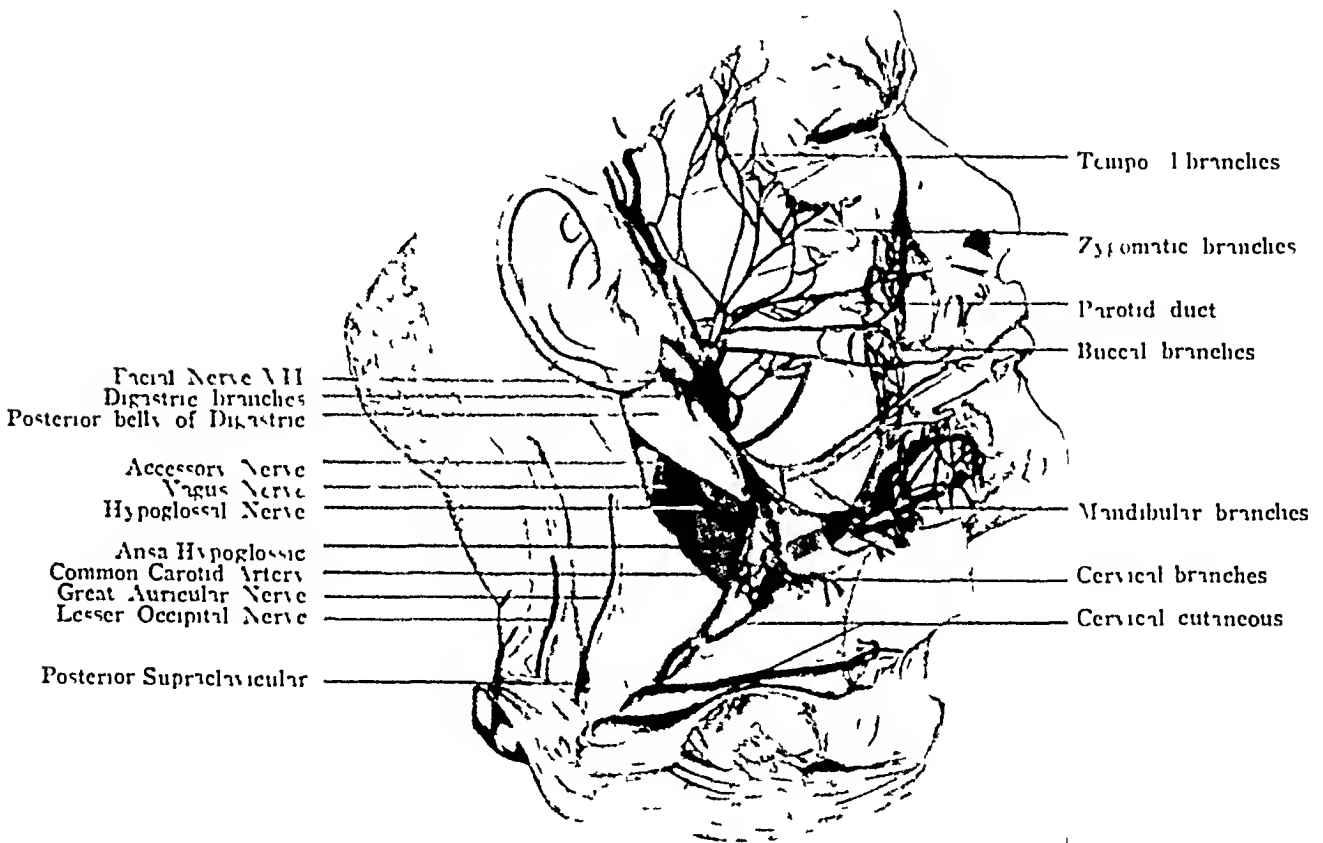


FIG 10.—Drawing shows minute dissection of the facial nerve. The parotid gland has been removed. There is wide variation in the nerve pattern but there is a consistent tendency to three plexus like arrangements in the three main divisions. The plexus of the mandibular branch is usually the most complex of the three. There seems to be a tendency for the nerve branches to avoid a space overlying the masseter muscle. The digastric branches are well shown. These are important in the identification of the trunk of the nerve in the operation for anastomosis. Gentle retraction downward on the digastric muscle will expose one of these branches which may be followed to the trunk with minimal dissection. Because of the plexus like arrangement of the nerve and the free anastomosis between the branches there may be considerable difference in the effects of lesions of similar location.

apparently destined for one group of branches may find a distribution in a remote group (Fig 11) ^{*} This very complicated arrangement of the nerve pattern and the free anastomosis between the various groups as well as individual branches may explain in part the difference between emotional expression and ordinary facial movement.

^{*} Figures 9, 10 and 11 are reproduced from drawings made at dissections in the Department of Anatomy, Medical College of Virginia, by Mrs Louise Jones

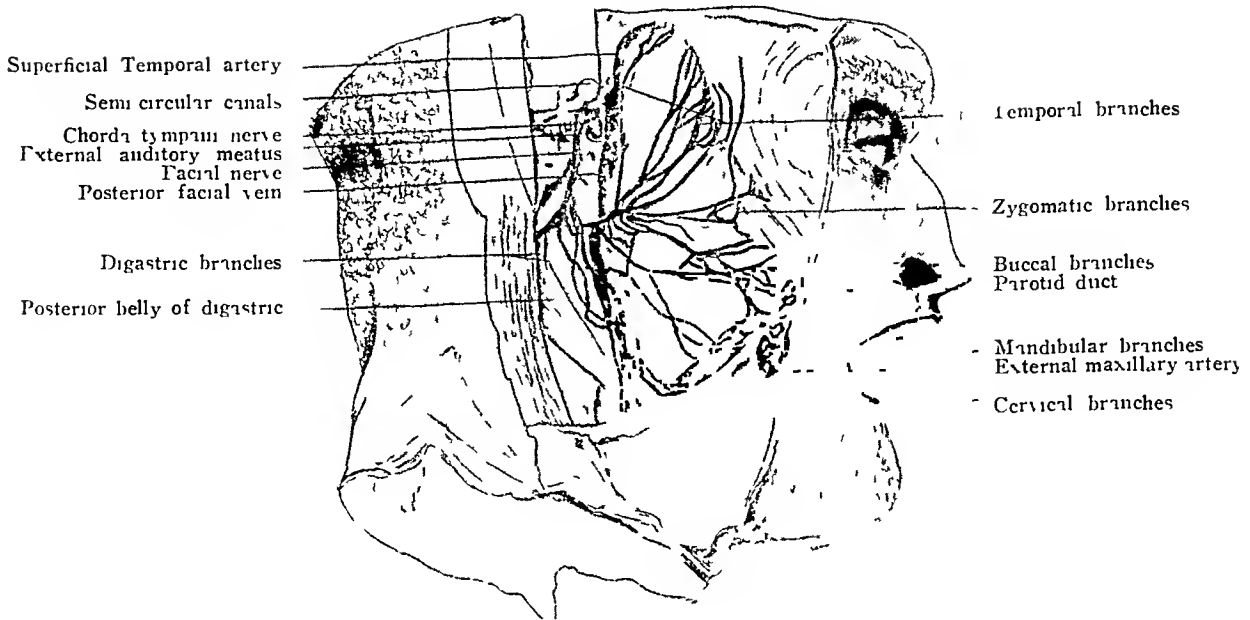


FIG 11—Drawing from actual dissection shows a complicated pattern of the nerve in the portion just distal to the facial canal. Several important branches arise from the trunk at this point. A division of the branches at the border of the mandible would be much more difficult to make than a lesion in the same location in the nerve as shown in Figure 10. In this particular case the plexus like arrangement of the distal branches is much less complicated.

CONCLUSIONS

The limitations to complete success of surgery of the facial nerve are obvious and apparently insurmountable. The principal cause of imperfect recovery of function after division of the nerve trunk appears to be faulty regeneration of the nerve. Whether the lesion is paralysis of the nerve or facial spasm for which paralysis must be produced for relief, the purpose of operation is to remove a conspicuous facial deformity. The facial muscles, once disconnected from their central control by trauma or severe disease of the nerve trunk, never recover the power of normal emotional expression. Motility can be restored to the paralyzed face by direct suture, nerve graft or anastomosis, depending on the type of case. Notwithstanding the permanent loss of emotional expression on the previously paralyzed side, great improvement is obtained by restoring facial symmetry, preventing atrophy, and protecting the eye. The results of surgery for facial nerve lesions are by no means perfect but it is possible to relieve a very depressing facial deformity by appropriate operative procedures.

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DIVERTICULA OF THE URINARY BLADDER*

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INCIDENCE

DIVERTICULUM of the urinary bladder is a complication of clinical importance in about 6 per cent of cases of obstruction at the vesical neck. Most of these are encountered in men between the ages of 50 and 70, with benign prostatic hypertrophy. The smaller incidence in men with carcinoma of the prostate can be explained by the fact that the period of obstruction is shortened by the life expectancy of carcinoma patients. The early spread of carcinoma of the prostate through the capsule and into the periprostatic region also lessens the degree of obstruction in these cases as compared with benign hypertrophy where the growth is confined to the capsule. The occasional cases occurring in children are usually associated with congenital lesions such as prostatic valves and contractures of the vesical neck. Scar tissue resulting from inflammatory conditions of the bladder and urethra is considered responsible for the small number of cases in females.

ETIOLOGY

Whether diverticulosis of the bladder is congenital or acquired is of little more than academic interest. Congenitally weak spots exist in the retro-trigonal region and the posterolateral walls near the ureteral orifices and the site of the urachus. These constitute what Kimbrough¹ termed factors of "soil preparation" always present in the vesical wall. Certainly, in the routine management of urologic patients one is impressed by the apparent immunity of the majority of bladders to the development of diverticula. Congenital obstruction at the neck of the bladder in children often progresses to the point of complete decompensation of the upper urinary tract without the formation of a diverticulum (Fig 1). However, in another child similarly obstructed for the same period of time a diverticulum will form (Fig 2). Acquired obstruction in adults shows an absence of this complication in approximately 95 per cent of cases. Thompson² and others have called attention to the fact that in cases in which diverticula do develop, the frequent association of other conditions, such as inguinal and diaphragmatic hernia, indicates a congenital weakness of tissue.

* Read before the Southern Surgical Association, December 7-9, 1943, New Orleans, La



FIG 1

FIG 1—Complete congenital obstruction at neck of bladder in child, age 5, without diverticulosis



FIG 2

FIG 2—Complete congenital obstruction at neck of bladder in child, age 5, with diverticulosis



FIG 3a

FIG 3a—Diverticulum with large orifice and sufficient contractile ability to empty, which produced no symptoms



FIG 3b

FIG 3b—Postoperative cystogram one month after operation (transurethral resection)

SYMPTOMS

There are no pathognomonic symptoms of vesical diverticula. Difficulty in urination, frequency, pain, hematuria, pyuria, incontinence and retention are frequent complaints. These are also symptoms of obstruction at the neck of the bladder and would not necessarily suggest the presence of a diverticulum. The so-called installment urination may be regarded as

presumptive evidence. In such cases the patient passes a small amount of urine and a few moments later a larger amount which may be extremely cloudy. Many of these pouches produce no trouble during life and are discovered only at autopsy. In these cases the opening of the diverticulum is usually large and the wall of the sac has sufficient contractile ability to

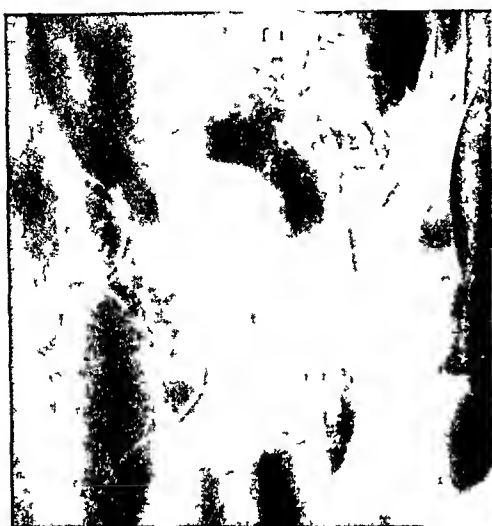


FIG 4



FIG 5

FIG 4—Infiltrating growth which has spread to bladder wall
FIG 5—Papillary growth which can be seen through the wide orifice of a shallow sac

empty, thereby reducing the possibility of infection, the chief source of symptoms (Fig 3a and 3b)

COMPLICATIONS

The complications of vesical diverticula are (1) infection, (2) stone formation, (3) tumor, (4) hemorrhage, (5) damage to the corresponding ureter, and (6) rarely rupture.

Infection is the most common complication of a diverticulum which does not completely empty itself. A weak wall of the sac and a narrow orifice through which it communicates with the bladder favor the development and persistence of infection once it has been established. In cases of long standing the infection may spread beyond the diverticulum to form dense adhesions to the surrounding structures.

Stones are found in about 12 per cent of diverticula of the bladder. A few of these may migrate into the sac from the bladder and kidneys. Those that form in the sac are probably the result of infection. This is especially true if the infection is caused by urea-splitting organisms which favor the precipitation of insoluble earthy phosphates.

Neoplasms found in vesical diverticula are of the same type that invade the bladder. They are not common, only 40 cases having been reported by 1932. Others have appeared in the literature since that time. We have

seen three cases two of which were infiltrating and had spread to the bladder wall (Fig 4) The other was a papillary growth which could be seen through the wide orifice of a shallow sac (Fig 5)

Hemorrhage unless profuse, is not necessarily a complication but may be regarded as a symptom of some other condition in the diverticulum

The corresponding ureter may be damaged by the presence of a vesical pouch in one of two ways A ureter opening into an infected sac favors ascending infection to the kidney, in addition, the diverticulum may be of sufficient size to produce partial obstruction to the lower end of the ureter by pressure with dilatation of the ureter in the renal pelvis above The combination of infection and retention predisposes to calculus formation in the renal pelvis just as it does in the diverticulum Although not common, this complication may be serious when it does occur

Rarely does a diverticulum rupture, but it may occur when there is a sudden increase in intravesical pressure especially if infection has rendered the wall friable This complication assumes the same clinical importance as extravasation of urine from any other cause

DIAGNOSIS

The diagnosis of vesical diverticula is based on a careful cystoscopic study of the bladder and roentgenologic studies of the entire urinary tract Cystoscopy under favorable conditions offers the most accurate means of obtaining information about the bladder On the other hand in cases with diverticula, cystoscopy alone is not completely diagnostic It indicates the position and size of the orifice but gives no information as to the depth and contents of the sac or the ability of the diverticulum to empty itself It must be remembered also that nearly all of these patients are of advanced age, with prostatic obstruction and some degree of renal and cardiovascular damage Because instrumentation in such patients is followed by an occasional serious reaction, it is our policy to complete all other studies first This routine has enabled us to obtain sufficient information in the majority of cases from roentgenologic, and other studies, to make the indications for treatment apparent Thus, in the majority of cases cystoscopy is not performed until the patient is anesthetized and ready for operation An exception to this routine is made when the history, physical findings and roentgenologic studies indicate the presence of a tumor in either the bladder or diverticulum

Roentgenologic studies of the urinary tract include a plain film of the kidneys, ureters and bladder, intravenous urograms and retrograde cystograms The plain film may indicate a diverticulum by the presence of a suspicious shadow lateral to the bladder region (Fig 6) It will also determine the presence or absence of stones in other parts of the urinary tract Excretory urograms in the presence of good renal function and adequate preparation will provide accurate information regarding the condition of the kidneys and ureters Cystograms obtained in connection with intravenous urograms



FIG 6
FIG 6—Presence of di

FIG 7
FIG 7—Retr
culum suggested by suspicious shadow lateral to bladder
de cystogram showing diverticulum of bladder

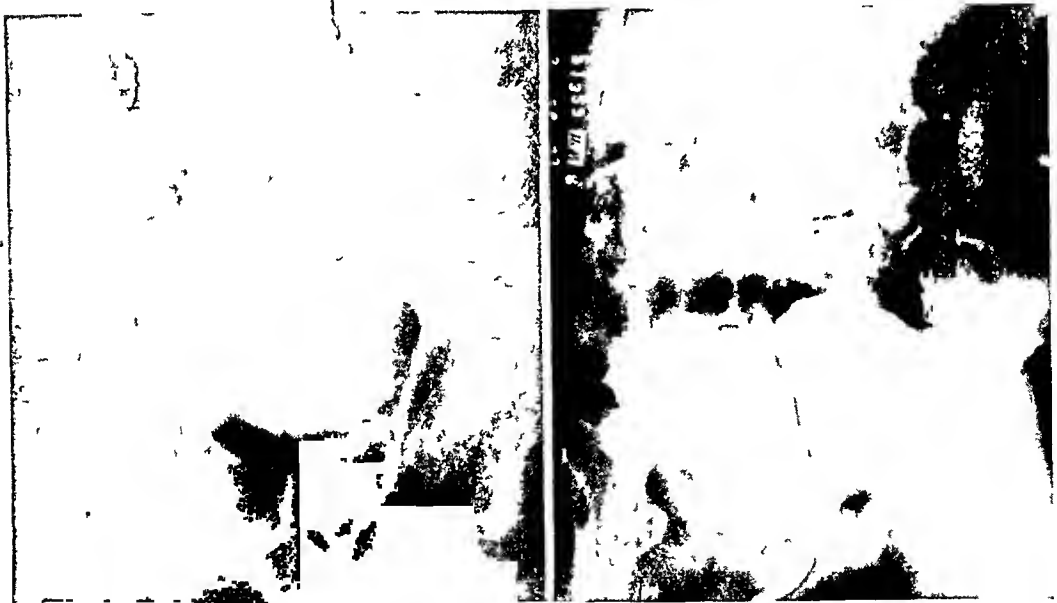


FIG 8
FIG 8—Anteroposterior view demonstrating diverticulum of bladder

FIG 9
FIG 9—Lateral view showing vesical diverticulum

are not always diagnostic, in which case retrograde cystograms are necessary (Fig 7). Exposures are made in the anteroposterior right and left lateral positions, 5 per cent sodium iodide being used as a contrast medium. If a diverticulum is present, it is usually seen on at least two of the films (Figs 8 and 9). A fourth exposure, made after the bladder has been emptied by catheter, will indicate whether or not the diverticulum is of the retentive type (Fig 10). In the absence of a stone, any filling defect in the divertic-

ulum may be produced by the tumor projecting into the bladder. It may be possible to

Bladder spasm will sometimes interfere with cystographic studies. In some cases, a small amount of spinal anesthesia may be used to facilitate both examinations. The importance of cystographic studies in all bladder neck obstructions is emphasized by the frequency with which one encounters complications from diverticula in these cases. Adequate studies to determine the presence and type of diverticulum are, of course, routine

Cystoscopy in such cases may show the diverticulum. If the diverticular orifice is large, one can advance the cystoscope into the sac. The purpose of both cystoscopic and cystographic studies is to determine the size of the diverticulum. Intravenous pentothal or a small amount of spinal anesthesia may be used to facilitate the satisfactory performance of both examinations. The importance of cystographic studies in all bladder neck obstructions is emphasized by the frequency with which one encounters complications from diverticula in these cases. Adequate studies to determine the presence and type of diverticulum are, of course, routine



FIG 10
FIG 10—Cystogram made after bladder has been emptied
FIG 11—Preoperative cystogram of diverticulum of bladder

TREATMENT

The development of prostatic resection as a means of relieving prostatic obstruction has brought about a more conservative viewpoint toward the treatment of vesical diverticula. This attitude has been demonstrated by Thompson, *et al*,² who made a comparison of cases of diverticula seen during two six-year periods at the Mayo Clinic. During the first period (1926 to 1931, inclusive) 107 diverticulectomies were performed, whereas during the second period (1932 to 1937, inclusive) there were only 30 primary and five secondary diverticulectomies, in spite of the fact that a greater number of patients were treated for bladder neck obstructions in the latter period. The size of the diverticulum alone does not constitute an indication for removal (Fig 11). Many of these fairly large sacs with a wide orifice will contract to the point of almost complete obliteration (Fig 12), or will produce no symptoms following removal of the obstruction at the neck of the

bladder Diverticula with a large capacity and a narrow orifice communicating with the bladder are usually of the retentive type and require removal, particularly if they are badly infected

Diverticulectomy should be performed in all cases with complicating stones except with the possible exception of a small low grade tumor where the size of the shallow sac is large enough to permit visualization of its cavity and destruction of the tumor with a high frequency current There should be no question as to the grade of the tumor, however, when this procedure is performed



FIG 12

FIG 12—Postoperative cystogram of same patient

FIG 13

FIG 13—Large diverticulum situated deep in pelvis

Any one of several operative techniques for removal of diverticula may be carried out The extravescical dissection of the sac, as practiced by Lowsley and others, is easily performed in the case of large diverticula not attached to the surrounding structures by dense adhesions (Fig 13) After the bladder has been incised down to the orifice the neck of the sac may be severed from the bladder and the diverticulum removed in a retrograde manner similar to the retrograde removal of the gallbladder This method is especially applicable in diverticula complicated by tumor In such cases it may also be necessary to excise a portion of the adjacent vesical wall to insure complete removal of the growth If the ureteric orifice is involved in the diverticulum, the Y-plastic, developed by Young,⁴ offers a good means of preserving the normal ureteric insertion into the bladder Reimplantation of the ureter into the bladder should be avoided if possible Ligation of the ureter should also be avoided because of pyonephrosis which frequently develops in the kidney above necessitating nephrectomy Occasionally, the corresponding ureter and kidney may be sufficiently damaged by dilatation and infection to necessitate an additional operative procedure Suction of the sac into

the bladder by means of a large glass tube, also devised by Young,¹ offers a method of removing multiple diverticula in some cases. The orifice is closed and the diverticular space drained extravasically. Correll² recently advocated the use of a rubber balloon attached to a catheter to effect the intravesical removal of a diverticulum.

To remove the entire sac of a large diverticulum situated in the pelvis and adherent to the surrounding structures is often a tedious and consuming procedure. In 1939 Baines³ offered a simple approach to this problem which involves the principle of removing the mucous membrane from the diverticulum and leaving the remainder of the diverticulum in place. The bladder is exposed through an adequate suprapubic incision and the lateral wall incised down to the diverticular orifice. The orifice is then opened wide to expose its intracavitary nature. By incision or dissection the mucous membrane lining is removed. In the long run, present for a long time, the mucous membrane is thickened and may come away. Baines advocated the use of the cutting-current to destroy pieces of mucosa difficult to remove. The cutting-current may be used for this purpose. The cutting-current causes less tissue damage than the cautery and may be used to remove the entire mucous membrane. The orifice of the diverticulum is closed after the mucous membrane has been removed. This converts the diverticulum into an extravasical pouch which is drained by a cigarette drain or Penrose tube. A cystostomy tube is left in place to divert the urinary stream. The length of time the tube is left in varies in individual cases. We have used this method in several cases in which the diverticulum was large, situated deep in the pelvis and surrounded by adhesions and in one patient with a diverticulum containing stones and frank pus (Fig. 13). It is easy to perform, rarely requires more than an hour to complete the operation and produces little more shock than simple suprapubic cystostomy.

In cases requiring removal of obstruction of the neck of the bladder in addition to diverticulectomy, it has been our routine practice to remove the diverticulum first. We can think of no reason for reversing this procedure. Thompson² has pointed out that transurethral resection in borderline cases does not seriously complicate the performance of diverticulectomy if this is later found to be necessary. An increased amount of infection in secondary diverticulectomies is a factor that may contribute to a prolonged post-operative recovery.

Transurethral resection of the margin of the diverticulum is a dangerous procedure which fails to accomplish the aim of the operation. The margin of safety is small and extravasation of urine is liable to follow.

Within a week or ten days following diverticulectomy transurethral resection or prostatectomy may be performed. If the obstruction is relieved by transurethral resection, the suprapubic catheter may be removed at the same time and the wound allowed to close. If sufficient tissue to relieve the obstruction has been removed, the suprapubic wound heals promptly.

SUMMARY

Diverticulum of the urinary bladder is most often seen in men between the ages of 50 and 70, with benign prostatic hypertrophy. The development of diverticula should probably be ascribed to congenital and acquired factors. The symptoms are not pathognomonic and may even be absent. Complications include infection, calculus formation, tumor, hemorrhage, damage to the corresponding ureter and rupture. The diagnosis may be made from thorough cystoscopic study of the bladder and complete roentgenologic studies of the entire urinary tract. In regard to treatment, the trend is toward conservatism. Retentive diverticula which are badly infected and diverticula associated with stones or neoplasms are indications for removal. Any one of several operative techniques may be employed for removal of diverticula depending on the conditions found in the individual case. We prefer performing the diverticulectomy first in cases requiring treatment of obstruction at the vesical neck as well as removal of the diverticulum.

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DISCUSSION—DR W. E. LOWER, Cleveland, Ohio. I am very much interested in these two papers because they represent two important urologic problems. They have both been very well presented and treated in a most efficient, conservative way. There are certain factors in diverticulum of the bladder which Doctor Burns brought out and which I think might be repeated for the sake of emphasis.

My own observation leads me to believe that congenital factors do play a rather important role in the development of diverticula, otherwise, we should have more diverticula in elderly people who have obstruction, and yet only a small percentage of cases of prostatic hypertrophy have diverticula. The congenital factor was brought out clearly by Dr. Ernest Watson, of Buffalo, in 1923, before the Urological Section of the American Medical Association. He showed by dissection of the fetus in various stages, certain defects that might predispose to diverticula, especially when to this congenital defect was added some obstruction of the bladder outlet. In our own series of cases, which is just under 100, the percentage in women was only 3.9 and in all of these cases there was some obstruction to the urethral outlet, something that prevented easy emptying of the bladder—for example, stricture or caruncle. In cases that require operative intervention to the extent of removing the diverticulum, we have found that by packing the sac with gauze, converting it into a semisolid tumor, the operating for removal of the diverticulum is made much easier.

Doctor Burns has shown that in many of these cases of diverticulum of the bladder associated with obstruction, when the obstruction is relieved the symptoms often subside.

and nothing more need be done to the diverticulum. Occasionally a diverticulum will contain a tumor. We have had six such cases and, in that event, of course the diverticulum must be removed. In many cases calculi will be found in the diverticulum and, as a rule, in most of these cases the diverticulum must be removed.

Doctor Burns has well emphasized the question of avoiding cystoscopy in elderly people with prostatic obstruction. It is much better to do it at the time you are prepared to treat the obstruction by transurethral resection and thus avoid the reaction that so often comes from cystoscopy without relief of the obstruction. Whenever we do a cystoscopy, we always give the patient sulfathiazole for about three days following the examination and I believe in this way we avoid many of the reactions that used to follow indiscriminate instrumentation in these elderly people often is followed by marked reaction, and I have seen a number of cases in which death followed such instrumentation, especially through the use of metallic instruments.

Doctor Cone brought out the importance of not being in too much of a hurry to bring down these undescended testes. I have seen too many catastrophes occur in an early operative attempt, and I refer principally to the interference with the blood supply, followed by atrophic changes. I think most men who have had experience with this type of case feel that we should wait until puberty, because in many cases the testicle will enlarge at that time and descend into the scrotum, or at least further down toward the scrotum so that it makes the operation much easier and more promising. I believe we are not conservative enough in many of the lesions of the genito-urinary tract, and until we recognize that certain congenital deformities may not interfere with function, we had better let them alone rather than try to correct them for cosmetic reasons. I refer particularly to certain types of hypospadias. Take the glandular hypospadias, many individuals never know they have it until somebody calls their attention to it when they are adults, and then they are anxious to have something done. I believe a genito-urinary surgeon who has had much experience will agree that, as a rule, you make the condition worse rather than better, and yet the Navy insists that glandular hypospadias must be corrected. It should occur to them that it is not a condition that can be acquired in the service, and certainly does not in any way interfere with function. The same is true of hydrocele in elderly people. The operation on a hydrocele means admitting the patient to the hospital the loss of two or three weeks' time, and the result often times is just a hard, tender testicle afterwards. At this particular time, when labor is so much in demand, I have found that by aspirating these cases, which can be done under local anesthesia at the office, these men do not lose any time and may not need to have it retapped for from four to six months. I think we might extend this conservatism to even the upper urinary tract and not be in too much of a hurry to do plastics on the hydronephroses until you have pronounced symptoms. Many of these cases must have some type of operation but I have followed a number in a conservative way by ureteral dilatation, and they have been able to carry on without any great inconvenience.

If all this sounds too conservative, I want to assure you that it comes from my clinical experience over a period of years, and not because I am less keen to operate when I think it necessary, but I believe that it takes years of experience and many failures in too radical a procedure to establish this point of view.

DR MALCOLM D THOMPSON, Louisville, Ky. I have had no experience with cryptorchidism in children, but my associates and I have performed the Thorek operation upon 20 young adults. In addition, we have examined a number of other patients upon whom the Thorek operation was performed elsewhere. We believe the operation to be justified and of great value—if for no other reason than the tremendous improvement in morale experienced by the patients. As one colored patient surprisingly expressed it, "Doctor, no longer can my friends call me one gone Jones."

It is essential to bring the testicle into the scrotum and onto the thigh without tension. To accomplish this we do not hesitate to divide all the structures entering the testicle, with the exception of the vas and its deferential artery. Doctor Cone said he did not believe the deferential artery sufficient to nourish the testicle in children. As stated, we have had no experience with the operation in children and we do not know whether or not the artery is sufficient in children, but we do know that it is sufficient in young

adults if the testicle is sutured to the thigh without tension. In addition, we have found two procedures to be most helpful. The vas must be gently and patiently mobilized and in some cases as far posteriorly as the seminal vesicle. Also, by dividing the deep epigastric vessels and the other structures of the inguinal floor, the vas deferens can be brought directly out the pelvis at the external ring, thereby shortening the distance between the seminal vesicle and the scrotum. Even with these aids, occasionally a testicle cannot be brought into the scrotum without tension and we think in these cases, excision of the testicle is advisable, provided there is a normal testicle upon the opposite side.

COL BRADLEY L. COLE, New York City. I would like to discuss Doctor Cone's paper, and to call attention to its completeness, for it covers most of the controversial points and takes a definite position on them. I would like to subscribe to most of the statements he brought out. Our experience with gonadotrophic stimulation at the Hospital for Ruptured and Crippled* has been unfavorable in those cases in which we felt that descent of the testes had been delayed rather than permanently arrested. There may be some benefit in such cases as those associated with a Froelich syndrome, but hormone therapy in cases of ectopic testes has not been felt to serve any useful purpose, and most of these cases do not present any stigmata that would suggest the need for its use. On the other hand, failure of descent of the testis in a patient with a true Froelich syndrome does not constitute an indication for surgery. A large series of school children were observed by an Australian surgeon for a considerable period of time, and he found, by frequent examination over a period of years, that the majority of those whose testes had not descended when first seen, showed a gradual subsequent descent. He referred to them as instances of "delayed descent." Obviously, operation upon such cases before descent had normally occurred would be unwise. It is partly for this reason that we have felt that operations should be deferred until just before puberty rather than at the age of five or six years which some earlier authorities preferred, and we have been impressed with the better results obtained in cases where the operation was done at this later period.

I should like to bring out a technical point which is valuable but has seldom been described. In operations for undescended testes, and especially in the ectopic variety, the gubernaculum has an abnormal attachment and does not tend to lead the testis to its proper location in the scrotum. With a retractor held in the lower angle of the inguinal incision, a layer of fascia is seen. It is a natural tendency to assume that the testis should be placed beneath this layer rather than superficially to it. However, if this is done, the testis will never reach its normal location in the scrotum, but will come to lie in an abnormal position in the upper thigh. Instead one should place it anterior to this fascial layer between it and the skin for this layer leads directly to the scrotum.

Incidentally, many of us have seen cases operated upon for hernia where the testis had always occupied a normal position, but following the operation the organ remained high and never regained its scrotal situation. The most frequent cause of this distressing complication is the failure to replace the testis inadvertently drawn up into the lower angle of the wound during hernia repair, in its normal compartment which has been described previously.

In 1926, Burdick and I reported on the results of 537 cases operated upon by the Bevan method. Satisfactory end-results were seen in only about 50 per cent. It was our belief that the failure of the development of the scrotum was the principal factor in the unsuccessful cases. In 1932, we reported 137 cases in which the Thorek procedure was used, with 123 excellent or satisfactory results, or approximately 90 per cent. The Thorek operation requires that scrotal skin be sutured to the skin of the thigh. Firm union does not appear to take place quite as promptly as is the case in ordinary skin incisions, and there is often a slight tension on the suture line. Therefore, to avoid the embarrassment of having the scrotum separate from the thigh, it is advisable not to remove the stitches too early. This complication is one of the most important in contributing to an unfavorable result.

As regards operating upon cases of undescended testis occurring in soldiers, I am not sure that I agree entirely with Colonel Thompson's and Colonel Higgmbotham's

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position. While I accept the validity of their argument regarding the psychologic reasons for doing this operation, I cannot disregard the fact that three or four months' training is lost in correcting a condition which is congenital in nature, and saving an organ which is without spermatogenic value and whose hormone-producing functions are not essential in view of the normal testis on the opposite side. Doctor Cook has mentioned the use of a vitallium prosthesis in cases where orchidectomy was required. It might well be that such a prosthetic substitute could be the answer in some of these cases.

Dr. EDGAR BURNS, New Orleans, La. (closing). The first large diverticulum was operated upon by Doctor Lower's technique, it facilitated removal a great deal.

Dr. ROBERT E. COLE, Galveston, Texas (closing). I have little to add, but should like to show one lantern slide. Here you see our results after the Thorek operation. You will note we can depend on a low scrotal position following this procedure. In the 20 per cent in which structure was subnormal the blood supply of the testicle may have been injured in a few during the process of cord lengthening. In the remainder testicular development was anomalous or normal growth was deficient. Postoperative hormonal stimulation has been of no benefit in this group.

THYROID CARCINOMA WITH METASTASES STUDIED WITH RADIOACTIVE IODINE*

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IN 1942, in a preliminary note in Science we reported our first case of storage of radioactive iodine in a metastasis from a thyroid carcinoma. The patient was still under observation. We present now the completed report of this one case which was followed until death, and in which the autopsy findings are of considerable interest. Our original statement about the time of removal of the primary growth must be corrected. The patient had deliberately falsified her history, and it was only after her death that, through her relatives, we were able to ascertain the facts.

CASE REPORT

M R, PH No 652642 Negro, female, age 39, single, houseworker, was admitted to St Luke's Hospital, New York City (St L's Hosp No 259205), June 27, 1934, complaining of a swelling of the neck of seven years duration. The mass had been the "size of a quarter" for the first five years, but in the two years prior to admission it had grown to the "size of a lemon," and gave her a sensation of pressure and obstruction to breathing on exercise. Through the courtesy of Dr Leila Charlton Knox, Pathologist, we learn that an encapsulated, extremely vascular tumor was removed June 28, 1934, from the isthmus of the gland (S P No 47764). This measured $7 \times 6 \times 5$ cm and had the appearance of an adenoma of the fetal type (Fig 1). There was never any local recurrence demonstrable clinically.

On September 2, 1941, seven years after operation and 14 years after the tumor was first noticed, the patient sustained a pathologic fracture of the left humerus. This occurred with a minimum of trauma. She had been supporting a considerable part of her weight on her left arm while filling a clothes hamper when she experienced sudden severe pain high up in the left arm, accompanied by an audible crack. She was admitted to the fracture ward of the Presbyterian Hospital where physical examination showed no palpable deformity. There was marked limitation in abduction because of pain. A roentgenogram (Fig 2) showed areas of bone destruction in the shaft of the humerus near the deltoid tubercle, and a small fracture line on the medial border. The patient then acknowledged having had transient pains in this region for several months. The rest of her history, as given then, was irrelevant. She denied any illnesses or any operations.

On general physical examination, there were only two significant findings. The first was a soft, pulsating oval tumor mass about 8 cm in diameter projecting 4 cm above the scalp in the region of the left parietal bone (Fig 3). This the patient considered a wen, and said it had been growing for about seven years without pain. There is no record of its presence, however, in her chart at St Luke's Hospital. The second finding of interest was a low collar scar present in the anterior neck. The thyroid gland was barely palpable and not nodular. The patient denied knowledge of the scar but, finally,

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† This investigation was aided by a grant from the Josiah Macy Jr, Foundation

after intensive questioning, found a friend who "remembered" that an operation for tumor had been performed when the patient was five years old!

Further roentgenograms showed areas of bone destruction in the lower end of the right femur (Fig 4), the upper end of the left femur (Fig 5), and in the left parietal bone (Fig 6) underneath the "wen," where there was a defect involving the inner as well as the outer table. Films of the chest showed some increases in the lung markings throughout, with rather prominent peribronchial fibrosis at both first and second interspaces on the left, interpreted as fibroid tuberculosis. This had been noted at St Luke's Hospital seven years earlier. The patient's sputum was never positive, and

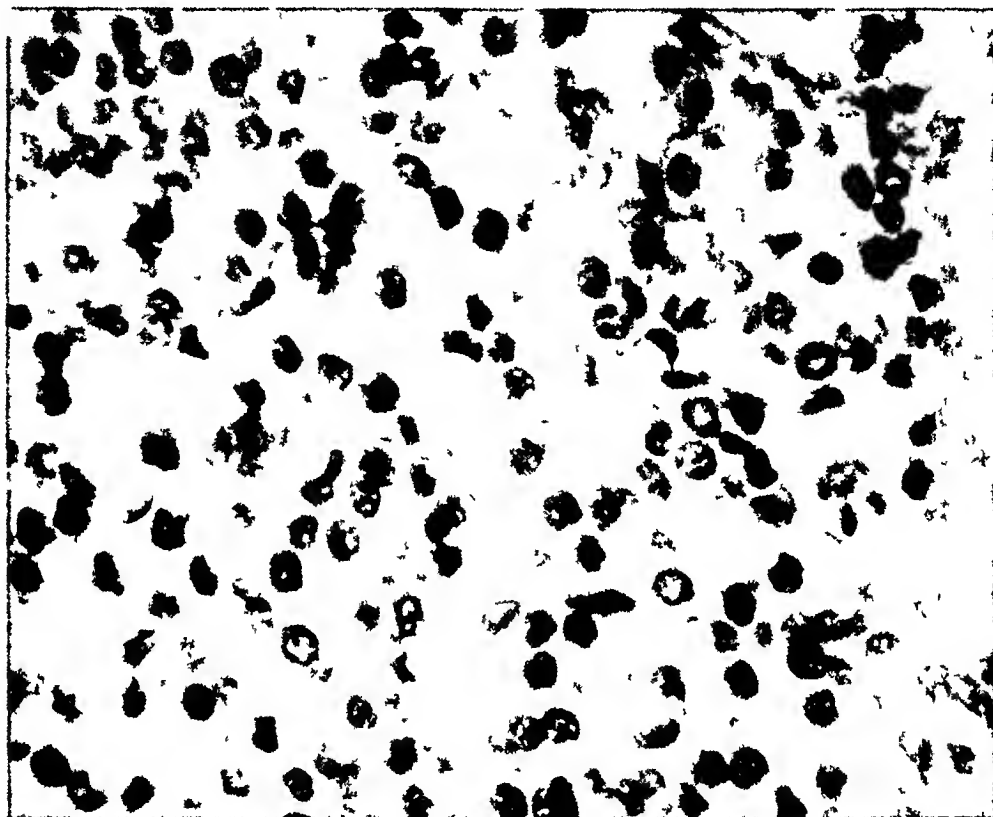


FIG 1—St. Luke's Hosp. No. 47764. Photomicrograph ($\times 875$) of encapsulated tumor removed June 28, 1934. Courtesy of Dr. Francis Carter Wood. The photograph shows a tumor with the appearance of a well-differentiated adenoma.

her only suggestive history was a single attack of "pleurisy" many years before. Serum calcium, phosphorus, and phosphatase were within normal limits. There was no Bence-Jones protein in the urine.

The left arm was placed in a swathe bandage and sling and radiotherapy was begun. A needle biopsy of the tumor in the left parietal region yielded a small blood clot, 2 mm in greatest diameter. On microscopic examination (Fig 7), an adenomatous tumor was recognized, with a few small colloid follicles. It was thought at the time impossible to obtain any further information about the original tumor. Subsequently, however, it could be compared with the sections made at St. Luke's Hospital, as shown in Figure 1. When the nature of the tumor was recognized, basal metabolic rate and serum cholesterol determinations were made. These were within normal limits and remained so throughout her course.

Considerable progress had been made with radiotherapy before a first tracer dose of radioactive iodine was given. In the first seven weeks 3400 r was given through four portals to the lesion in the humerus, using 200 K V, 1 Mm copper, and 1 Mm aluminum filtration at 50 cm anode-skin distance. Two weeks after treatment had begun and about 1200 r had been given, the pain had almost completely subsided, and at the

end of the treatment the patient was free from pain although abduction of the left arm was limited to about 70° . The patient continued to work during the treatment. About three weeks after irradiation was given to the left arm and eight weeks following the fracture the patient complained of pain in the right lower thigh. A dosage of radiotherapy (1200 r) was given this area through one anterior and one posterior portal, using the factors noted above. The patient also complained of throbbing in the scalp tumor, and this showed an increased amplitude of its pulsations. Accordingly, 600 r was given through one portal, using the same factors as above. A dosage of 600 r was given the left upper thigh through one portal. For reasons which are not certain, the pulsations



FIG 2—Roentgenogram of the left humerus. April 19, 1942 showing bone destruction. This had been the site of the pathologic fracture.

in the tumor of the parietal bone decreased markedly after 600 r, and the tumor became much softer.

Treatment to these two fields was then interrupted for the administration of a tracer dose of radioactive iodine (eight-day half-life). This was obtained through the courtesy of Prof. E. O. Lawrence, of the University of California. It was given orally in water on December 5, 1941. The substance was taken up, as shown by the Geiger counter, in considerable quantity by the metastasis in the right femur, and by the



FIG 3—Photograph of patient February 7, 1942, showing epilation over tumor in the left parietal region following treatment 600 r. Subsequently there was a regrowth of hair in this region.



FIG 4—Roentgenogram, January 16, 1942, showing bone destruction in the lower extremity of the shaft of the right femur.



FIG 5—Roentgenogram April 19, 1942, showing bone destruction in the proximal portion of the shaft of the left femur and lower margin of the left ilium just above the acetabulum



FIG 6—Roentgenogram of skull April 19, 1942, showing an area of bone destruction in left parietal region

thyroid gland. It was not stored in any appreciable quantity in the other bony metastases. As the parietal bone lesion was soft, almost fluctuant, it was considered possible that spontaneous, or radiotherapy-induced necrosis, might account for lack of storage in these foci. After this, as well as after other tracer doses, the rate of disappearance of radioactive iodine from the right femoral metastasis paralleled closely that of the thyroid gland. The radioactive iodine in both the thyroid gland and in the right femoral metastasis could not be "washed out" by the administration of 54 mg of potassium iodide, which indicates that the iodine was bound in these foci, probably in organic combination.

Because of the localization in the metastasis, however, it was suggested that a larger dose might afford selective therapeutic "internal irradiation," and ten millicuries was

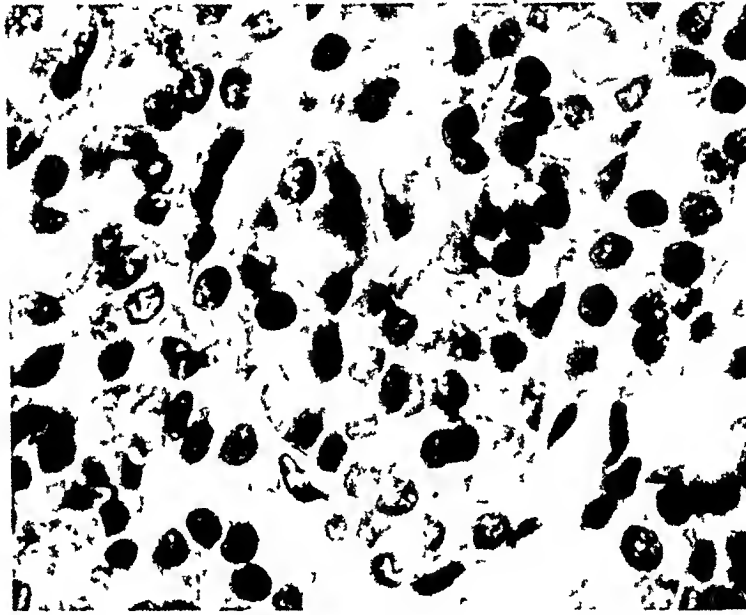


FIG 7—S. P. No. 79954. Photomicrograph of the tumor showing four small colloid follicles, all that were found in the tiny needle biopsy from the skull metastasis.

accordingly given, mainly of the 126-hour period, obtained through the courtesy of Prof. Robley D. Evans of the Massachusetts Institute of Technology. Again there was localization, about 6 per cent of the material in the thyroid and about 30 per cent in the right femoral metastasis. Radio-autographs of the latter were made by placing a film on the patient's thigh. The area on the film darkened by the radiation tallied with the localization obtained by the Geiger counter and by roentgenograms.

The right femoral metastasis showed no change in radioactive iodine content during the first week, but when measured again at the end of three weeks showed loss of 85 per cent of its radioactive iodine. A tracer dose given a few days later showed no further uptake by the metastasis although there was new localization in the thyroid. This was interpreted at the time as evidence of the effectiveness of this "internal irradiation." At least the iodine fixing function of the metastasis had been impaired, and it was hoped that the growth and multiplication of the tumor cells might also have been inhibited.

Blood and urine samples were taken at intervals after administration of the therapeutic dose, and the amount of radioactivity determined (Charts 1 and 2). These curves might be of interest in other cases where radioactive iodine might be used in calculation of the amount of radiation delivered in the body before localization of the radioactive iodine. Since there is an appreciable period where large amounts of radioactivity are in the body before localization, it should be possible to deliver proportionally more radiation to

regions where localization occurs, by using the eight-day period of iodine rather than the 126-hour period. However, the radiation is here administered slowly and would not be as effective as the same number of roentgens delivered by the shorter-lived isotopes.

The patient remained in apparent good health until July, 1942. Repeated roentgenologic examinations failed to show any appreciable change in the areas of bone destruction. In July, 1942, she awoke one morning with a feeling of numbness and tingling in the legs. Roentgenograms made at this time were interpreted as showing no new lesions.

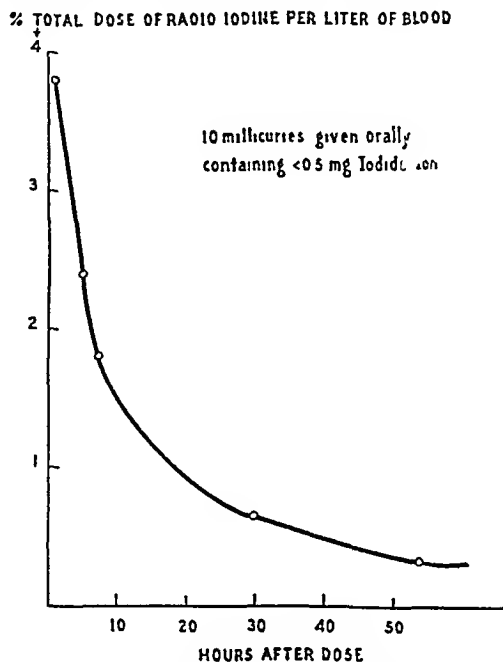


CHART 1—Curve showing percentage of total dose of radio iodine per liter of blood

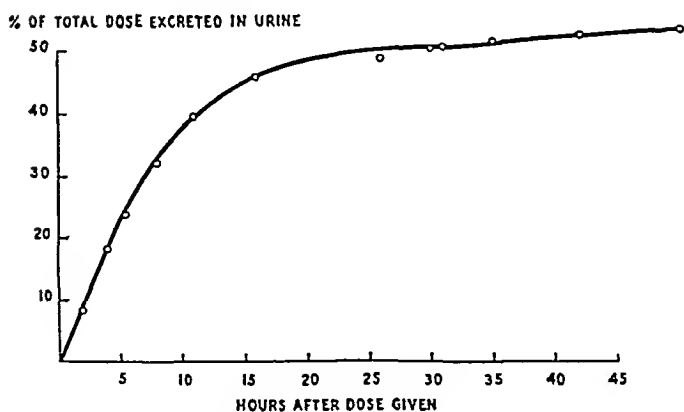


CHART 2—Curve showing percentage of total dose of radio iodine excreted in the urine

The patient became discouraged and failed to keep clinic appointments, in spite of social service follow-up, from August 11 until October 26, when she was admitted to the hospital with loss of power in both legs. She said this had come on suddenly two weeks before admission, and that she had had pain in the back. Neurologic examination, by Dr. E. G. Zabriskie, showed a sensory level extending from the ninth thoracic down, in which pain and temperature were both involved, excepting the sacral areas. Touch was moderately diminished at the same level, but included the sacral areas. Vibration

was lost from the ninth segment downwards. There was profound disturbance of gross muscle power in both legs, the left more so than the right. There was a curious mixture of flaccidity and spasticity in both legs, with bilateral patellar and ankle clonus, and bilateral Babinski.

Roentgenologic examination (Fig 8) was reported as follows: "Films of the skeleton show a destruction of the pedicles of the 9th and 10th thoracic bodies on the left side, along the border of which there is a soft tissue mass, due to tumor which has invaded



FIG 8—Roentgenogram, October 26, 1942, of the spine, showing destruction of the pedicles of the 9th and 10th thoracic bodies on the left, with a soft tissue mass.

underneath the ligamentous investment of the spine. Apparently there is intraspinal tumor here which has grown out through the intervertebral foramen and then invaded on the outside of the spine as well. The body of the vertebrae itself is not badly involved."

Further careful review of all films, by Dr. Ross Golden, after the patient's death led to the finding of changes in these pedicles in the first skeletal films, taken at the time of the first hospital admission on September 9, 1941. The changes are slight, however.

Because of the definite clinical and roentgenologic findings of spinal metastases, a tracer dose of radio-iodine, obtained through the courtesy of John R. Dunning, of Columbia University, was given in November, 1942. This again showed uptake of

radioactive iodine by the thyroid and right femoral metastasis and did not suggest appreciable uptake in other regions. The femoral metastasis here took up about three times more iodine than the thyroid gland.

It must be kept in mind that a count obtained over a region with the Geiger counter depends on the gross composition of the tissues underneath it as well as on the amount of radioactive material present. The inverse square law of radiation is also a factor in the count, so that proximity to the radioactive source is of great importance. These factors make difficult the interpretation of counts not far removed from background especially in regions near foci containing large amounts of radioactivity, or over regions like the abdomen where moderate counts are obtained for several days because of some residual unabsorbed iodine, possibly in the organs, possibly in the large amount of blood subtended by the counter. This is especially true for the period of the first few days following dosage. The interpretation of the count over the small of the back was uncertain, because the counter subtended the abdomen and moderate counts of the same order were also obtained over the abdomen. While it was impossible with the amount of radioactive iodine made available in November, 1942, to exclude a spinal metastasis, it was not possible to state that the counts suggested any appreciable amount of iodine-containing tissue in the spine. Certainly nothing approaching the uptake of the right femoral metastasis or of the thyroid could be demonstrated in the vertebrae.

Palliative radiation was given to the lower thoracic spine, with striking relief of pain but no marked change in the paralysis. The patient was bedridden, but, when relieved of pain, in excellent spirits, optimistic, and in good general health. Further palliative radiation by roentgen ray was necessary for the spine in January, 1943, and for progression of tumor, now obviously invading soft parts, in the right humeral metastasis, in April and June, and the left upper femoral metastasis in May. Some relief was always obtained.

Various forms of physiotherapy were exhibited. The most effective, at least psychologically, was massage. In spite of steady increase in the size of her lesions her nutrition was maintained, and she required only codeine and aspirin for sedation. The patient had great faith in the radioactive iodine, and thought that further dosage might relieve her paralysis. It was not possible to obtain sufficient material for therapy, but two more tracer doses were administered as psychotherapy, in April and May. These again showed uptake of radioactive iodine by the thyroid and the right femoral metastasis. No other foci were demonstrable with certainty by the Geiger counter. The right femoral metastasis took up six times more than did the thyroid gland, which was about as much as it took up before the therapeutic dose of radioactive iodine.

It may be of significance that the right femoral metastasis which took up five times as much iodine as the thyroid gland before treatment with the therapeutic dose, took up no radioactive iodine three weeks after the dose was given, and had lost most of its radio-iodine. As time went by the uptake became larger (Chart 3) until the last tracer dose it took up, again, six times as much as thyroid. This would suggest a temporary impairment of the iodine storage function with a gradual restoration of function, very probably due to increase in size of tumor.

In May, after six months of bed care, the first indications of a downhill course were evident. The tumors grew more rapidly. Pain increased, and the patient began to run a fever. In June there was increasing edema of the whole left lower extremity, fever was higher and the patient had frequent, profuse diaphoresis. Morphine was not necessary, however, until eight days before death. Cough was not a symptom, but the patient had been taking fairly regular doses of codeine. The first roentgenogram to show striking lung lesions was taken July 1, after a sudden change for the worse initiated by a shaking chill. On review of previous films, even with the knowledge of the distribution of lesions at autopsy, Dr. Ross Golden felt that no definite diagnosis of lung metastases could be made before this date.

Following the chills the patient rapidly became weaker. Her white blood count, which had been followed throughout her course because of the radiation therapy, rose, reaching 21,600, with 87 per cent polymorphonuclear leukocytes. Labored respirations were first noted on July 11, irregular fever and rapid pulse continued, and she died on July 20, 1943, 16 years after she first noted the tumor, and nine years after its local removal. Because of the unreliability of the history it is not possible to say how long she had clinical evidence of metastases before death, but five years seems a conservative figure.

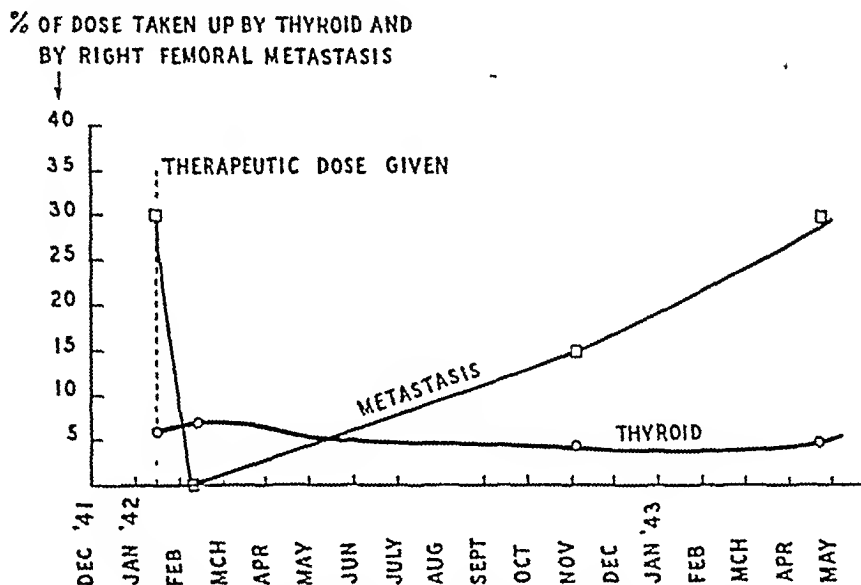


FIGURE 3.—Curves showing percentage of total dose of radio-iodine taken up by the thyroid and by the right femoral metastasis.

It had been our intention, if therapy failed, when the patient was obviously in *extremis*, to administer a final dose of radio-iodine so that, if permission for autopsy were granted we might be able to make a quantitative analysis of the uptake and demonstrate by radio-autographs the material in the tissues as it might be selectively absorbed. The patient's death, in spite of her long course and obviously terminal stage, was unexpectedly sudden at the end, and the radio-iodine was not administered.

Autopsy—This was performed 28 hours after death by Dr. Clarence Schubert, of the Department of Pathology, with a final anatomical diagnosis as follows:

CARCINOMA OF THYROID

Obsolete operation: Thyroidectomy

Secondary carcinoma in thyroid with extension to parathyroid, heart, lungs, pleura, diaphragm, liver, adrenals, kidneys, and bones (parietal—left, with extension to dura, humerus—left, femora and vertebrae—T 9—L 2 inclusive, with extension to extradural tissue of thoracic cord)

Myelomalacia—T 10—T 12

Edema of lung

Acute serofibrinous pleurisy, with hemorrhage

Fatty liver

Medial degeneration of aorta

Myomata of uterus

Polypus of uterus

Polyp of colon

Melanosis of colon

Foreign body in peritoneal cavity—detached appendix epiploica



FIG 9—Autopsy No 14184 Photograph showing 1.2 cm tumor nodule in the lower pole of the left lobe of the thyroid



FIG 10—Autopsy No 14184 Photograph of lung showing multiple metastatic nodules

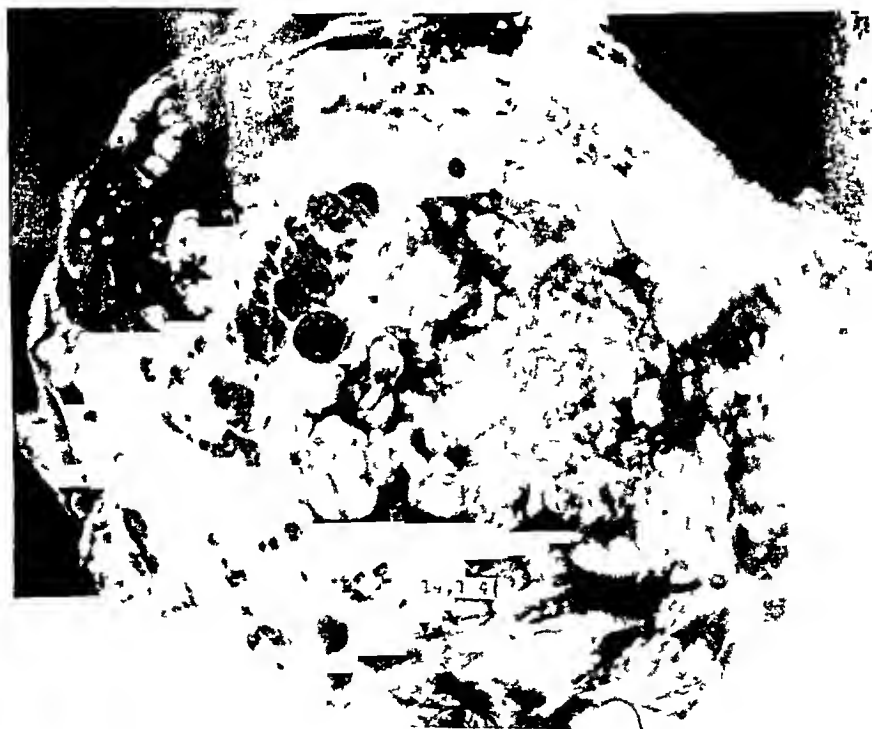


FIG 11—Autopsy No 14184 Photograph of diaphragm showing multiple metastatic nodules in pleura

The significant gross findings externally were the excellent state of nutrition and the absence of any decubitus, the mass in the left parietal region, the swollen left upper arm, with discoloration and peeling of the skin following irradiation, and the edema of the lower extremities.

On section, there were certain striking features. There was a tumor in the thyroid gland, which was found, with no other gross lesions in the gland, as a 1.2-cm nodule in the left lower lobe (Fig 9). It was circumscribed, but not encapsulated, firm and pale yellow-



FIG 12—Autopsy No 14184. Photomicrograph of left parietal bone showing metastatic nodule.

gray. There were multiple metastases in the lungs (Fig 10) and pleura (Fig 11). *No lymph nodes were involved.* The osseous metastases corresponded in their distribution with that shown in the skeletal films. A portion of the parietal bone was removed for study (Fig 12), and showed the tumor adherent to the dura but not extending to the brain. The tumor tissue from the other bones, with the exception of that in the vertebrae, was obtained through small exploratory incisions, and the gross involvement was not seen.

The other metastatic lesions were less dramatic. The interesting feature of the metastases, however, was the absence of any gross resemblance to thyroid tissue, except in the tumor removed by curette from the lower end of the right femur, which had consistently shown iodine uptake during life. This was soft, pale, red-brown tissue, with the color and consistency of thyroid. The other lesions, pulmonary, pleural and osseous, which had shown no iodine uptake, were soft, mottled yellow and gray, often necrotic, but not suggestive of thyroid.

FIG 13

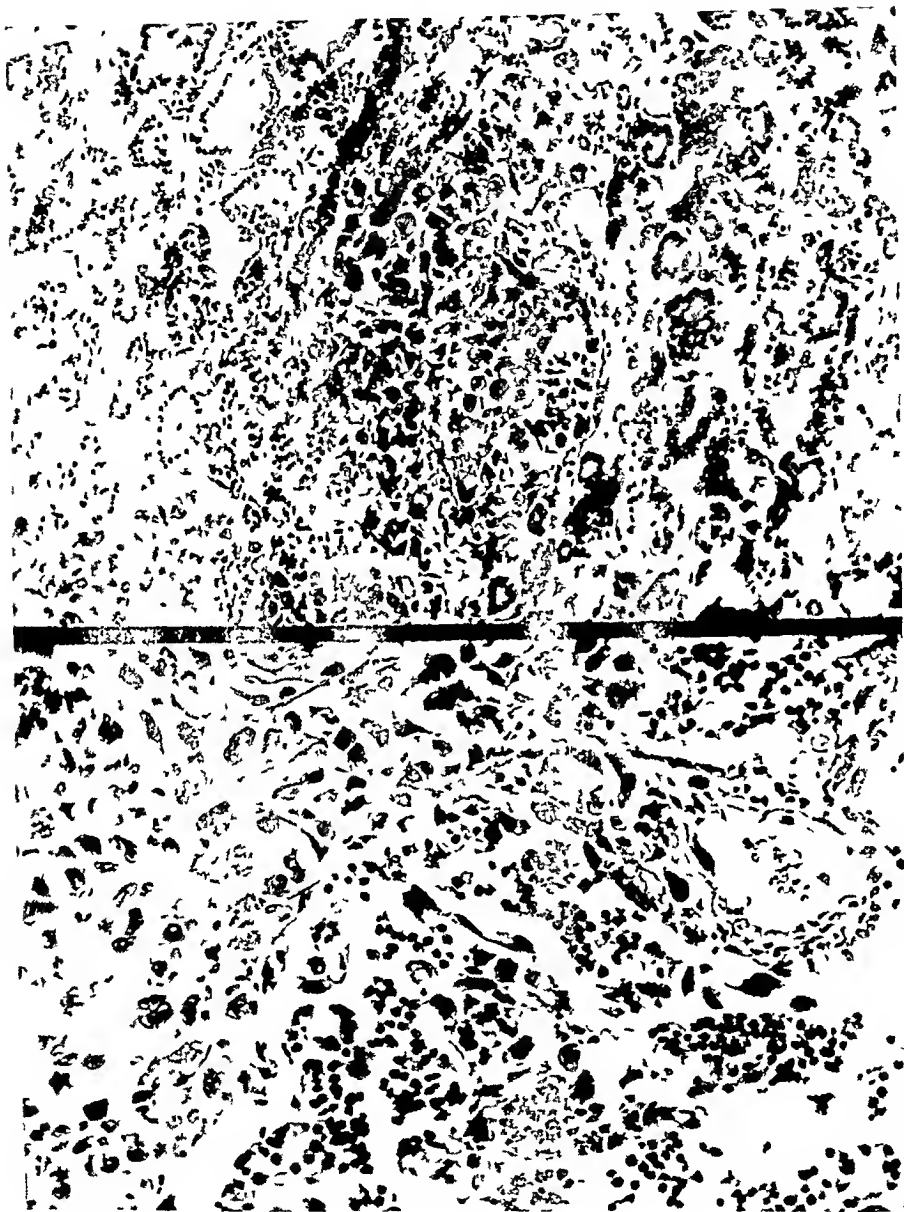


FIG 14

FIG 13—Autopsy No 14184. Photomicrograph of tumor from right femur a field showing some undifferentiated tumor. A great bulk of this metastasis, however, was well differentiated.

FIG 14—Autopsy No 14184. Photomicrograph of tumor in thyroid showing undifferentiated carcinoma without colloid follicles.

RADIOACTIVE IODINE

Fig 15

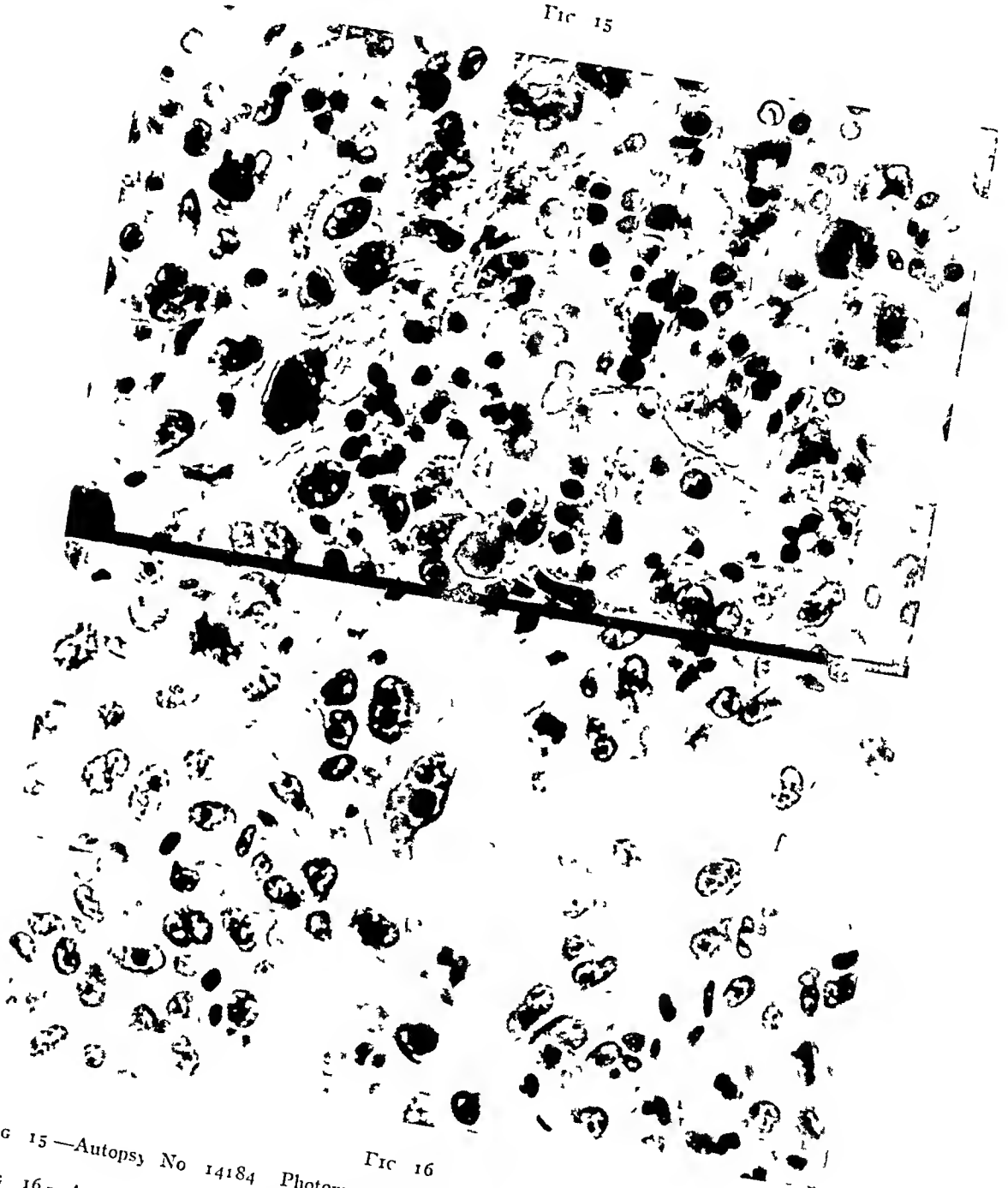


Fig 16

- Fig 15—Autopsy No 14184 Photomicrograph of tumor from lung showing anaplasia and multinucleated cells
- Fig 16—Autopsy No 14184 Photomicrograph of tumor from heart showing bizarre gigantic cells

FIG 17

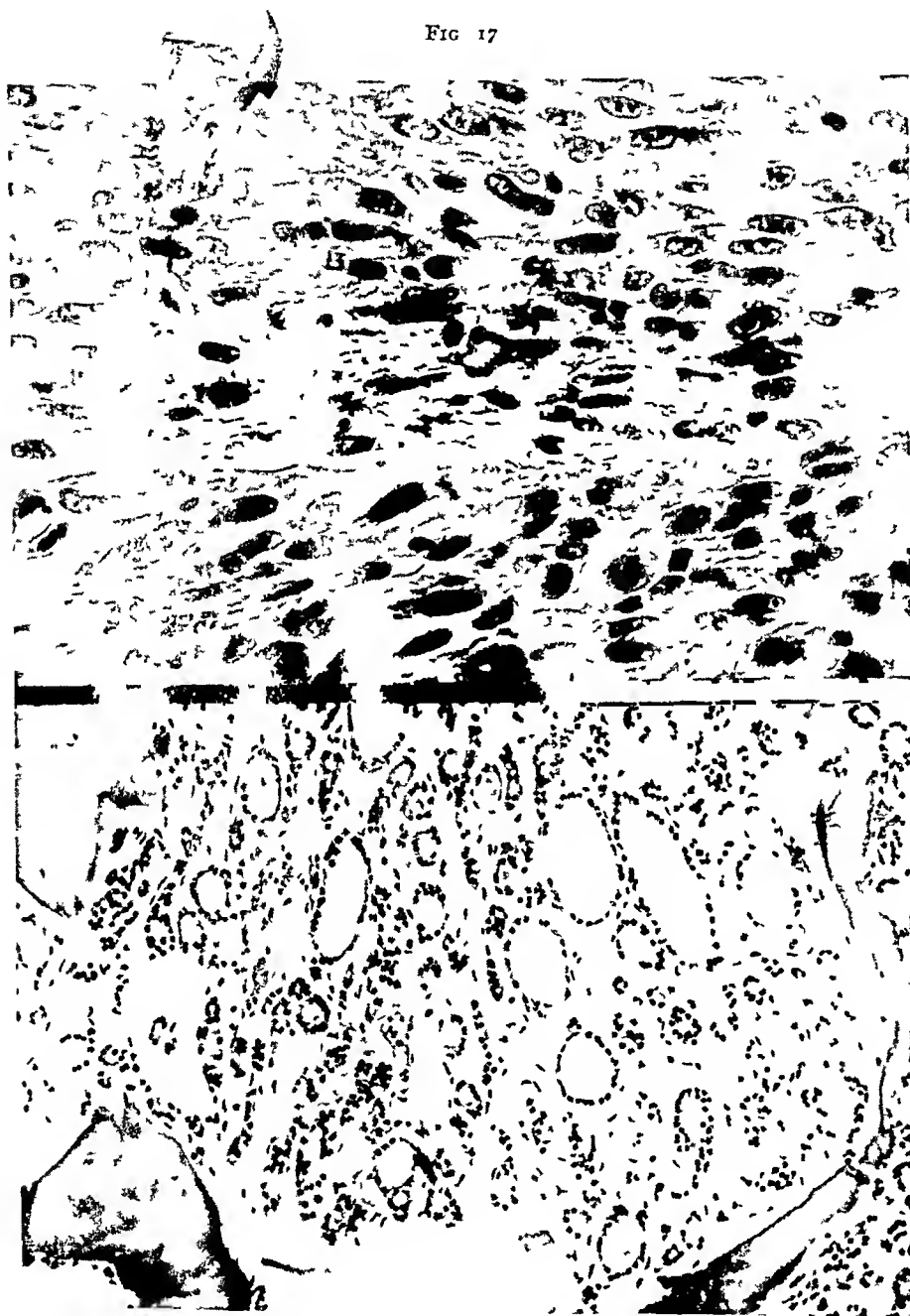


FIG 18

FIG 17—Autopsy No 14184 Photomicrograph of tumor from the liver showing spindle cell metaplasia

FIG 18—Autopsy No 14184 Photomicrograph of tumor in the 11th thoracic vertebra an illustration of the highly differentiated form with colloid follicles

Microscopic Examination The microscopic study of the different lesions confirmed the impression received from the gross examination, that this was a most unusual type of thyroid tumor. Most of the tissue from the right femur (Fig 13) was well differentiated, made up of small acini lined by flattened epithelium. These varied somewhat in size, but were all smaller than the average size of normal thyroid acini. Some contained colloid, and others a faintly eosinophilic granular precipitate. In a few small areas, however, there was undifferentiated tumor.

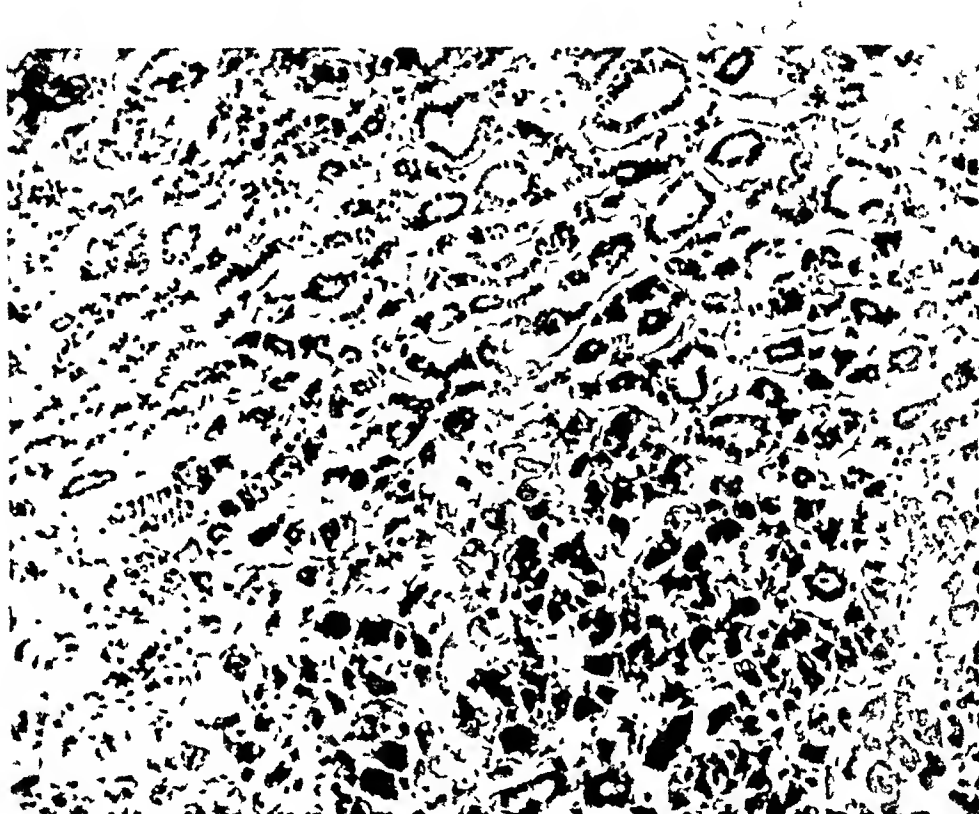


FIG 19—Autopsy No 14184. Photomicrograph of tumor from left femur, a field showing varying degrees of differentiation.

This undifferentiated tumor, which was found to compose the bulk of all the other lesions studied, including the nodule in the left lobe of the thyroid gland (Fig 14), bore no resemblance to normal thyroid or thyroid adenoma. It was composed of cells which varied widely in size, shape, and staining characteristics (Figs 15, 16 and 17). For the most part they were large, irregular, often elongated polyhedral structures, with eosinophilic cytoplasm and very large irregular nuclei, often containing large quantities of chromatin. Multinucleated forms, often gigantic, with large nuclei, were common. In almost all of the cells not in mitosis there were within the nuclei large globular eosinophilic masses surrounded by a clear zone. Most commonly there was only a single one of these inclusions, but as many as five were occasionally seen within a single nucleus. In most high power fields there were three to five mitotic figures, but, in addition, there were nuclei which appeared lobulated, or partially divided, as well as the binucleated and multinucleated forms. The mitotic figures were very irregular and frequently multipolar.

Differentiated tumor, however, was found, as has been said, in the bulk of tissue from the right femur, and also, in less amount, in the parietal bone and the 11th thoracic vertebra (Fig 18). No significant uptake of iodine had been demonstrated in the latter two sites. From the gross appearance of these lesions it seems probable that the bulk of the tissue was undifferentiated. In some fields there was at one extreme rather typical thyroid-like tissue, with colloid secretion, and in others, the wildly anaplastic

tissue described. Intermediate between these two types there was occasionally a solid adenomatous, or sometimes tubular arrangement, closely resembling the original tumor. These three types of tissue might be found in the same metastatic nodule, notably in the left femur (Fig. 19), but they were usually distinguishable even if there was intimate intermingling of the cell types.

II.

DISCUSSION.—It is of some interest to review briefly the historical background which led to this clinical investigation. It should be emphasized that carcinoma of the thyroid varies in its clinical course and that this, to a certain extent, can be correlated with the histologic appearance of the tumor. The highly malignant anaplastic carcinomas which have no organoid arrangement, produce no colloid, and grow with extreme rapidity often causing death by local disease alone, cannot be expected to function as thyroid. A small group of tumors midway between the completely undifferentiated and the highly differentiated forms do not suggest, from their morphology, that much endocrine activity might be expected. But the more benign forms do suggest functional tissue. These, often grouped under the misleading heading of "adenoma malignum," the very term being a contradiction, fall into two main groups and constitute, in our experience, the great majority of thyroid cancers. These two groups are for the most part clear-cut clinically and pathologically. There is the papillary form, often colloid-containing, which is exceedingly common when the tumor involves lateral aberrant thyroid tissue, and which metastasizes usually to lymph nodes and later to the lungs. This type rarely involves bone. There is the type which resembles embryonal, fetal or simple adenoma and is often so well differentiated as not to suggest neoplasm histologically even in the metastatic deposits. This type may be enucleated and without local recurrence be found, often several years later, widely disseminated in the bones.

Historically, recognition in this form dates back to Muller (1871) who noted with interest, the similarity to the normal organ in the primary tumor as well as in the metastases. Eberth (1872) reported such a case in a dog. Runge (1876) failed to recognize the import of a vertebral tumor containing colloid follicles. That same year Cohnheim wrote the now famous article on "Simple Colloid Goiter with Metastases."

The question of the possibility of function in these tumors was raised by Gulliver in 1886, when he reported a case of myxedema in which the symptoms were not relieved by the development of a thyroid carcinoma with metastases. But the proof of the potential function came shortly afterwards in 1894, and has never, to date, been so dramatically repeated. von Eiselsberg reported a woman who, after total thyroidectomy by Billroth, in 1886, developed myxedema and tetany, which disappeared three years later with the growth of a metastasis in the sternum, so proved by operation.

The next step in the study of the metastases of these well differentiated tumors in which colloid had been apparent grossly and microscopically, and to which the terms "benign metastasizing goiter," "wuchernde struma," and "adenoma malignum," had been given, was chemical analysis for iodine

content. Iodine has been demonstrated in such metastatic deposits by Ewald (1866), Gierke (1902), Stein (1904), and Meyer-Hurlman and Oswald (1913). Other investigators failed to demonstrate iodine (Regensburger, Maine, Zapelloni, Wegelin and Abelin, Eisen). Excellent summaries of these tumors are by Branovacky-Pelech (1926), and Simpson (1926). In addition, Simpson's article abstracts the cases to date and adduces strong evidence that all these osseous metastases, however much they resemble normal thyroid, or benign thyroid adenomas, are carcinomas with a primary growth in the thyroid.

Another approach to the study of function in these tumors is the analysis for active hormone. This was first attempted in animal experiments by Meyer-Hurlman and Oswald in 1913 in material obtained from fluid in a sternal metastasis. Twenty years later Engelstad (1933) obtained active thyroid colloid from a metastasis in the cranial vault, tested in mice as protection against acetantrile and repeated this on a bone metastasis in another case reported three years later. A year later Milles (1934) obtained from a case with lung and bone metastases an extract from the lung metastasis which accelerated growth and maturation in tadpoles. Similar biologic proofs with mice and tadpoles were given by Dickson, Diveley and Helwig (1940). They presented a case with a massive recurrence in which they considered that thyrotoxicosis had developed. This is not substantiated by their given clinical data, and no autopsy was obtained, so that the thyroid gland itself was not investigated. It is of some interest that similar studies have been made on thyroid tissue appearing, not as metastases, but as an independent tumor in the ovary "struma ovarii colloides," and that there is considerable evidence that this tissue also can function as thyroid.

When the radioactive isotope of iodine became available, it afforded a comparatively easy method of checking upon the physiologic function of iodine storage in metastases from thyroid carcinoma. The employment of radioactive iodine in the study of thyroid physiology has been carried out largely in two laboratories, the University of California, where Lawrence developed the cyclotron, and Evans, at the Massachusetts Institute of Technology in collaboration with Means of the Massachusetts General Hospital. The radioactive iodine produced by the cyclotron is mixed with inert iodine compounds such as potassium iodide, and usually administered, by mouth, although in certain experiments the intravenous route has been used. The proportion of radioactive to inert elements is one to 10^{10} or 10^{15} . The radioactive element behaves physiologically and chemically in every way the same as the inert, so that the radioactive element follows the course of the inert element in the body. The radioactivity in the tracer dose is kept so small that no effect on the organism due to its radioactivity occurs. The property of *gamma*-ray radioactive iodine makes it possible to follow its course in the intact animal by means of the Geiger counter.

In the early investigations with radioactive iodine the rate of absorption from the digestive tract was compared with four other radioactive ele-

ments sodium, potassium, chlorine, and bromine. When the radioactive elements were administered by mouth in isotonic solutions their appearance in the hand was noted within three to six minutes. There was little difference in absorption rates between the elements except potassium which was absorbed more slowly, after an hour only 48 per cent, while all others, 75 per cent to 85 per cent, had been absorbed.

Following these studies comes the observation that the thyroid gland takes up iodine selectively up to the point of saturation, as might be expected from earlier chemical analyses of thyroid glands for iodine. Hyperplastic and hyperthyroid glands take up more iodine than normal glands. Also it was observed that excessive amounts of inert iodine administered with the radioactive element reduced the amount of the latter which was fixed by the gland. This has a bearing on the use of iodine clinically. The average normal gland contains between 20 and 25 mg of iodine. Hyperplastic glands may have a much greater capacity for fixing iodine. After saturation further administration of iodine serves no useful purpose although there is certain daily turnover, greater in toxic than normal glands. To maintain saturation, therefore, a small daily amount of iodine is necessary. Indeed it has been shown that as good clinical effects can be produced by the daily administration of one drop of Lugol's solution containing 8 mg of iodine as by giving one cubic centimeter containing 120 mg.

Through the use of the radioactive element it has been shown that the thyroid gland of all types takes up iodine with great rapidity, i.e., within the first few hours after administration. However, a marked variation from normal occurs in the toxic goiter where, in from one to four hours, the maximum is reached and immediately the iodine is discharged until a saturated level is reached. The hyperplastic nontoxic gland falls in between the normal and toxic in that it reaches the maximum within the first 24 hours and holds it. The atrophied gland of myxedema takes up small amounts of iodine, and takes it up slowly. Hamilton, Soley, and Eichorn reported two cases of carcinoma of the thyroid studied by giving radioactive iodine before operation. The malignant tissue removed showed only one one-hundredth the amount of the tracer iodine found in the normal tissue taken at the same time. From the appearance of their photomicrographs, however, it seemed to us that they were not dealing with well differentiated types.

These observations lend support to previous ideas concerning iodine function. The normal glands are in a state of iodine equilibrium, although having the capacity to store a certain excess, if available. The hyperplastic gland is hyperplastic, according to the most widely accepted hypothesis, because of iodine insufficiency, hence its great avidity. With toxic glands the normal storage and release of the iodine containing hormone is lost. The gland is depleted of iodine, takes it up with great speed and in relatively large amounts, but is unable to hold all it takes up. This property of the toxic gland, as it concerns radioactive iodine, may possibly be useful in diagnosis in borderline situations. The reduced capacity of the atrophied

gland to take up iodine is what might be expected. As for the carcinomatous tissue, chemical analyses reveal low iodine content except in the adenoma malignum type.

In our own clinical investigation tracer doses of radio-iodine have been given to several cases besides the one reported in detail above. In two cases of colloid-containing bony metastases there was no uptake. One of these was a so-called Hurthle cell tumor, which might be functionless, but the other was a well differentiated adenoma malignum type. The lack of uptake in this latter case was a surprise, and the significance of the finding is not clear.

One case of a child with total thyroidectomy and possible metastatic tumor not demonstrable roentgenologically is being studied. The site of persisting disease has presumably been located by the Geiger counter and radioautographs. Further confirmation is needed, and this case will be reported later. In approximately 150 carcinomas of the thyroid in the Presbyterian Hospital we have no instance in which hyperthyroidism could be attributed to the tumor tissue. If such a case were ever found, the study might be most illuminating.

SUMMARY

A case has been reported, thought to be the first in which the function of metastases from thyroid carcinoma has been studied by means of radio-iodine storage.

Only one metastasis consistently showed appreciable uptake of the material.

At autopsy, the bulk of the metastatic tissue was undifferentiated. The metastasis which showed consistent uptake of iodine was the only one which grossly resembled thyroid tissue, and which, microscopically, showed chiefly well differentiated tumor.

No other case has come to the authors' attention in which thyroid carcinoma of the adenoma malignum type has shown anaplastic changes. The autopsy findings were a great surprise and are, we believe, extremely unusual. The histologic character of the undifferentiated type of tumor was such that an earlier fatal outcome might have been expected on the basis of previous experience with tumors of this morphology.

There was no clinical evidence that the radio-activity of the iodine was effective, in the amount given, in therapeutic "internal irradiation." It is possible that larger amounts might be effective in a lesion in which only well differentiated tumor was present.

We know of no evidence that external irradiation, by radium or radiotherapy, of thyroid carcinoma may change the histologic character of the tumor. We believe that two types of tumor were present in this patient before the administration of the radio-iodine as, from the outset, there was no uptake in most of the lesions with tracer doses.

CONCLUSIONS

Since some well differentiated tumors of the thyroid are capable of storing iodine, it is thought that in selected cases, possibly where the amount

of tumor tissue is small, effective therapeutic internal irradiation of metastases may be achieved with large enough doses of radioactive iodine. There should be minimal damage to other tissues because of the selective absorption of the doses of iodine may be valuable diagnostically, but only if there is localization. Failure of uptake does not mean that the tumor in question is not of thyroid origin.

Further study of thyroid carcinoma by this method is indicated.

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MODIFIED TECHNIC IN SKIN GRAFTING OF EXTENSIVE DEEP BURNS

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MANY REPORTS in the recent literature have emphasized the fact that all patients with extensive deep burns develop serious malnutrition as a result of the presence of a very large open wound^{1, 2, 3} This occurs despite forced nutrition, frequent transfusion of whole blood and the earliest possible skin grafting At this clinic we have had an opportunity to treat a moderate number of patients with deep burns of 30 per cent, or more, of the body surface The large majority of them have survived the stages of shock and burn toxemia, a few have died during the necessarily long stage of healing Thus any technic of skin grafting, which will speed the healing of a large burn wound may save lives We have developed two modified technics which have been useful Inasmuch, as neither of them has been stressed in recent books and articles on skin grafting, we have felt it worth while to report our experience

EARLY SURGICAL DÉBRIDEMENT WITH IMMEDIATE SPLIT-THICKNESS GRAFTING

Deeply burned areas, whether primarily treated by ointment or tanning methods, are ordinarily not free of slough and ready for grafting until the fifth week By the tenth day, however, the patient has usually passed through the phases of shock and toxemia, and is at that time in better nutritional condition than he will be at any other time during the phase of healing The body reserves of protein are not yet fully depleted and adequate serum protein levels can be maintained with the aid of high protein feedings Severe anemia may be prevented by blood transfusion Extensive surface infection of the burned area has not usually occurred because the wound is still sealed off by the densely adherent necrotic skin This would seem to be the logical time to start skin grafting, and experience has shown that grafting can be successfully accomplished immediately following a clean, sharp surgical debridement The debridement must be carried down to normal unburned tissue whether it be fat, fascia, or muscle By the tenth day it is always possible to recognize dead from living tissue Hemostasis is not difficult to achieve

Split-thickness skin grafts can then be applied to the freshly débrided areas and, in our experience, they take as well on these areas as they do on clean granulating surfaces They are cut, applied, and dressed by any of the accepted methods The initial dressings are changed at about the eighth day

We have used this technic on two extensively burned patients In the case which is summarized below, two early débridement and grafting operations

SKIN GRAFTING OF DEEP BURNS

were done on the 15th and 24th days, respectively. The result of the first operation is shown in Figures 1 and 2. Due to these early operations this patient had almost one-half of his wound already grafted by the fifth week, the time when, in most cases, grafting is just to be started.

Case Report—C. R. A 40-year-old mechanic's clothes caught fire, producing a complete third degree burn from ankles to gluteal folds. He was admitted to the hospital

FIG 1



FIG 2

FIG 1—Showing result of sharp debridement of posterior surfaces of legs on 12th day.
FIG 2—Showing the healthy appearance of initial grafts when dressed nine days after their application.

on June 30, 1943. The burned areas were superficially débrided, lightly washed, and dressed with vaselined gauze and thick pressure dressings. He received plasma continuously for the first 30 hours and frequent whole blood transfusions thereafter, as indicated. The primary dressings were changed on the 15th day. At this time, sharp surgical débridement of part of the wound was carried out under ether anesthesia, with the result shown in Figure 1. Four split grafts of about $\frac{1}{1000}$ -inch thickness were then cut by dermatome from the back and sutured in place under slight tension. The grafts and surrounding burns were dressed with sulfanilamide powder, vaselined gauze and pressure dressings. These dressings were first removed nine days later. The grafts were found to have taken almost completely (Fig 2). Further débridement was then carried out under anesthesia and

more grafts were cut from the abdomen and applied to the anterior surfaces of thighs and legs. This second grafting was on the 24th day. These grafts were dressed by the same method. More split-thickness grafts were applied on the 39th day. The patient was discharged on his 140th day, November 16, 1943, completely healed, after several minor pinch-grafting procedures.

FIG 3

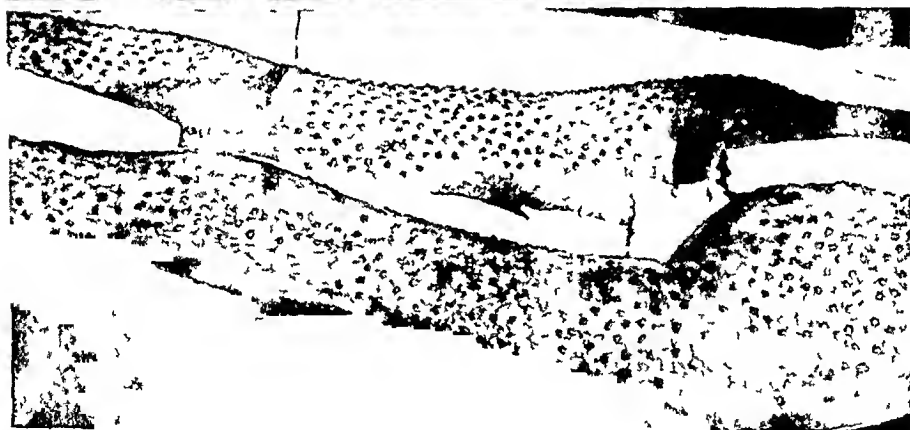


FIG 4

FIG 3—Showing the small donor site of right shoulder from which 850 grafts were removed on the 30th day.

FIG 4—Showing the 850 grafts in place on the day of operation. The anterior surfaces had been grafted ten days earlier.

MASSIVE PINCH-GRAFTING

An occasional patient with full-thickness burns of 50 to 60 per cent of the body surface will survive long enough to become a serious and difficult problem in skin grafting. The extensive areas must be rapidly covered if a slow downhill course, with eventual death, is to be avoided. These patients do not have large enough areas of normal skin to serve as donor sites for split-thickness grafts. Homografts may be used and, at times, may be life-saving, but in general they are unsatisfactory as they serve only as a temporary covering for the wound.⁴ Thus pinch-grafting often must be used in these cases.

In order to save life massive transference of skin must be undertaken as early as possible

The usual deep pinch or Davis graft is full thickness at its deepest point. The usual technic of cutting the grafts leaves normal skin between the individual donor holes. We have altered this procedure in that we use small grafts of less than one centimeter in diameter. They are cut superficially so that only an occasional pin point area of fat appears through the remaining layer of dermis. No normal skin is left between holes on the donor site. The small donor area heals rapidly and without the usual pock-marked appearance of pinch graft donor sites. It eventually becomes almost as smooth and even in appearance as an area from which a thin split graft has been taken. With this modified technic a very large number of small grafts may be taken from the relatively small donor area. Since each small graft spreads new epithelium from its whole periphery and since, with the large number of grafts, they may be placed quite close together, relatively rapid healing of large areas may be obtained. In the case reported 850 individual grafts were taken at a single operation from an area about eight inches square. They were applied to, and adequately covered, the buttocks and posterior surfaces of both legs.

Case Report—D. B. A 60-year-old emaciated, colored woman's house coat caught fire. She received extensive full-thickness burns of legs, buttocks, perineum, back and arms—a total of about 60 per cent of the body surface. She entered the hospital 12 hours later on August 28, 1943, at which time she was in shock. She received plasma continuously until the 30th hour. The wounds were dressed with vaselined gauze and pressure dressings. Pinch-grafting was started on the 25th day, by which time only a few small areas about the perineum were in condition to receive grafts. The anterior surfaces of the thighs and legs were covered with about 450 grafts on the 32nd day. On the 38th day 850 grafts were taken from the shoulder area and applied to the buttocks and posterior surfaces of thighs and legs. About 90 per cent of the previously placed pinches were found in healthy condition. Figures 3 and 4 show the relatively small donor area and the appearance of the grafted surfaces at the completion of the second operation, which was carried out under local anesthesia with small amounts of adrenalin added as a hemostatic agent. Despite frequent blood transfusions and the best supportive measures the patient died on her 48th day, October 15, 1943. The final group of grafts appeared to have taken very well when examined two days before death.

SUMMARY

Two modified technics of skin grafting have been presented. They have been found to be of assistance in the care of patients with extensive deep burns.

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FURTHER EXPERIENCE WITH THE TREATMENT OF BURNS WITH SULFONAMIDE-IMPREGNATED MEMBRANES

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SINCE THE PRELIMINARY REPORT¹ of the local treatment of burns with chemotherapeutic membranes the discussion and experimentation which were then being carried on with this and other methods have become even more extensive. As more experience has been gained in the handling of large numbers of burns under the stress of military or naval action, or in civilian catastrophe, the need for modifying technics to fit individual situations has become evident. Thus, it is recognized that what may be an "ideal" method of treatment in a civilian hospital, where the patient can be retained under close observation throughout whatever period is required and where sufficient personnel for elaborate routines is available, does not fit the exigencies of burn therapy near the front or aboard ships in action. A wide range of technics continues to be employed though the National Research Council has recommended the use of a bland ointment locally and sulfonamides by mouth. While such a method may have the advantage of simplicity and suitability to wide application by personnel of varied degrees of experience, it is still subject to criticism.

Since the initial report of ten cases we have continued to treat all burns with a sulfonamide-impregnated plastic film*. The plastic employed is methyl cellulose and the sulfonamides—20 per cent sulfanilamide and 10 per cent sulfacetamide—are buffered to a p_H of about nine, at which Schmelkes, and his associates² have shown these drugs to be most effective. The film is light, strong, and when applied to a "weeping" surface, or otherwise moistened adheres readily to its contours. The present report deals with an additional 57 consecutive cases of burns treated in the New York Hospital.

The routine treatment was as follows. In every instance shock was considered the matter of first concern and was treated in the usual manner, including plasma as required. When this was under control the local lesions were examined and simple debridement carried out in the accident room, but

* The film is manufactured and supplied by the Wallace & Tiernan Products, Inc., Belleville, New Jersey.

under sterile precautions. This consisted merely in opening blebs and lifting off any detritus but not in any extensive operative procedure.

The therapeutic membrane was then applied, either in strips or in sheets, as best adapted to the area involved, and in such a manner as to come into close contact with the burned area. In very moist areas more than one layer of the film was applied at the time of the original dressing and vaselined gauze was used in a few cases after the film was in place as a means of further sealing the dressing. For the most part, however, simple dressings of gauze sufficed and in all cases were covered with pads and so bandaged as to produce a moderate and even pressure over the involved area. In children a light layer of plaster was frequently used both for immobilization and to maintain the dressing in place.

The dressing was changed only when necessary and in many instances a single application of film was all that was required. In the more severe cases the outer dressing was removed and the burn inspected through the transparent film. It was noted that the membrane underwent one of three changes—it became dissolved by the fluid from the surface of the burn, it became dry and flaked into small pieces, or it remained dry, intact and following the contour of the area. If necessary, new film was applied over the old and recovered as before or, as in a few instances there was an accumulation beneath the film, it was completely removed and fresh reapplied. When an area was completely healed the remaining film was peeled away, soaking the more adherent areas with moist sponges.

Bacterial Studies—Numerous cultures were made from the burned areas both at the time of the first and of subsequent dressings. Positive cultures were frequent throughout the period of treatment but in only two cases were clinical signs of infection present in connection with second degree burns and one of these was a patient who had been burned six days previous to her entry into the hospital. All third degree areas showed growth on culture and generally obvious infection until healing took place.

The most common organism found was *Staphylococcus aureus*, while more rarely *beta* hemolytic streptococcus, nonhemolytic streptococcus *gamma*, diphtheroid bacilli, *B. proteus*, *B. subtilis* and *C. welchii* were encountered.

The film, through gradually liberating sulfonamide as it is dissolved, exerts a definitely bacteriostatic effect but cannot be considered as actually sterilizing the burned area. Indeed, a rather frequent finding beneath the film was a membrane of fibrin which, on microscopic examination, contained enmeshed leukocytes and some bacteria. The presence of this membrane was a source of some concern at first but as it became apparent that epithelization continued beneath this and that healing was not retarded, its removal was not considered necessary. Such a fibrin membrane may, in fact, be a part of the healing process in burns since we have found it present in experimental human burns treated by other means, such as with bland ointment and pressure dressings.

RESULTS

The age of the 57 patients included in this report ranged from nine months to 73 years, and the burns were all of thermal origin. Two cases, both infants with burns of over 70 per cent (Berkow's method) of the body surface, died within 48 hours of admission. Almost all of the burns appeared on inspection to be of second degree severity, but our experience with another method of determining this point³ leads us to feel that many small areas in which the epithelium is completely destroyed may be present in what appears to be a pure second degree burn.

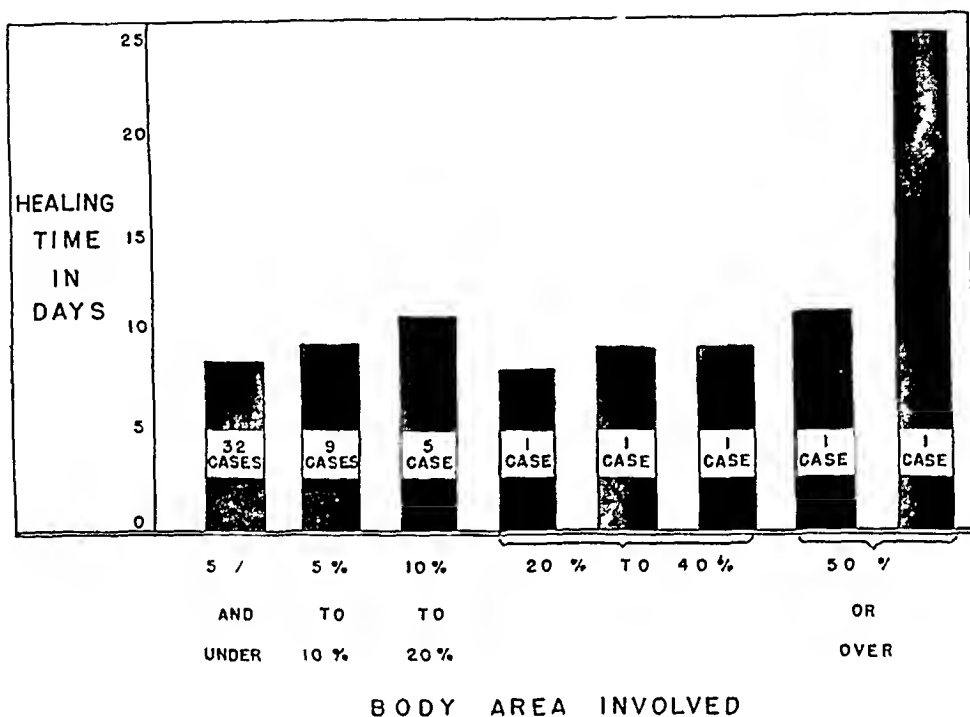


FIG 1—Graph showing the healing time of second degree burns

Thirty-two of the series involved 5 per cent, or less, of the body surface, and these had an average healing time of 8.4 days, the extremes being four and 16 days respectively—the latter representing a single exception. Burns involving 5–10 per cent of the body surface numbered nine, all of which healed in almost exactly nine days. In five patients the burns involved 10–20 per cent of the body surface and these healed on the average in 11 days. There were three patients with burns involving 20–40 per cent of the total body area and which healed in eight, nine and nine days, respectively, and two cases with 50 per cent, or more, of the body surface burned which were completely healed in 11 and 25 days. Although the burns were widely distributed over the body, we were unable to correlate the speed of healing with any given part except the face, where epithelization is uniformly faster.

COMMENT—Reference to Figure 1 reveals the fact that in this series with the exception of a single case, the size of the burn bears little relation

TREATMENT OF BURNS

to the time required for healing. The most obvious explanation would seem to be that epithelization takes place from multiple foci, such as the cells about the base of hair follicles which being relatively evenly spaced over a given region become connected in about the same length of time regardless of the total area involved. The aim of therapy of such burns should, therefore, be to facilitate the operation of this mechanism as much as possible. To this end the mode of treatment should be of such a sort as to avoid mechanical or chemical injury to the remaining viable tissues as well as to control infection since these are the chief hindrances to healing.

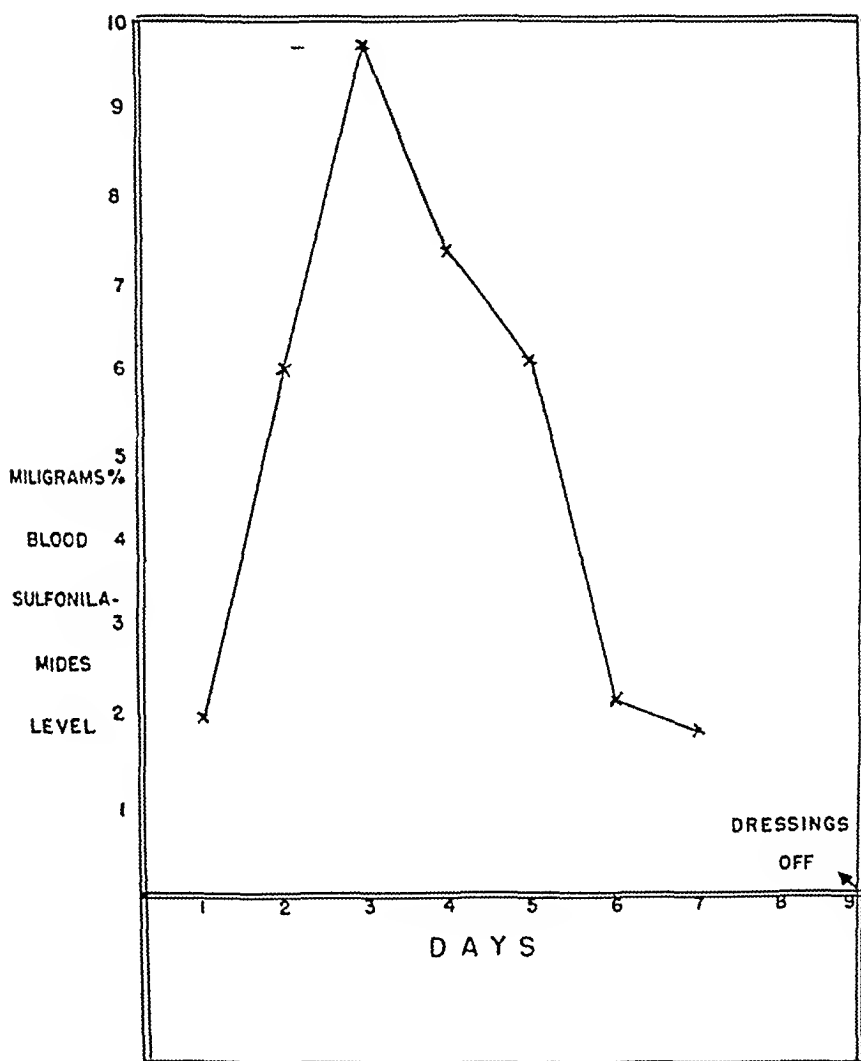


FIG. 2—Graph showing highest blood sulfonamide levels from local absorption in this series. The patient was an infant with burns of more than 50 per cent of the body surface. Note the fall of blood levels as healing progresses.

All burns are contaminated in their early stages but gross infection is usually absent so that strong antiseptics are not required. All that is needed is a bacteriostatic agent and a means of preventing further contamination. For this purpose the Subcommittee on Surgical Infections of the National Research Council and the Contaminated Wound and Burn Project under the Committee of Medical Research of the Office of Scientific Research and Development⁴ have recommended the employment of a bland ointment locally

and the administration of sulfonamides by mouth. While this may be a simple and most useful treatment in the field, we do not feel that it is the ideal mode of therapy since in our experience it is associated with a definitely longer healing time than some other methods.

It is these very criteria plus the great ease of application which brought about the development of the chemotherapeutic membrane. During our own experience with it the film has been improved by varying its composition. At present it is .004 inches thick and is constituted as follows: The base is methyl cellulose-triethanolamine to maintain a pH of about 5.5, and the sulfonamides employed are 20 per cent sulfanilamide and 10 per cent sulfacetamide. One square centimeter of the film contains three mg. of sulfonamide. The choice of the ingredients is dictated by a number of factors. The pH is adjusted to that point at which the maximum activity of the contained sulfonamides is reached.

No ill effects have been noted from the use of the film and although three patients had previously had local application of sulfonamides, no allergic manifestations have been observed. The local liberation of sulfonamide from the film is readily demonstrable since measurable blood levels have been obtained. These have usually been quite low and in proportion to the area involved, but in one patient, an infant with more than 50 per cent of the body surface burned, a maximum of 9.7 mg. per cent was reached (Fig. 2). There seems to be a gradual liberation of the drug from the film and absorption into the blood stream.⁵ Despite a relatively uniform supply available in the film, which may be renewed at intervals, the blood levels tend to fall as healing progresses, and, indeed, the curve of such levels constitutes a fairly accurate index of epithelization.

Other striking features of this method are the rapid relief of pain and the relative speed with which the burn surface ceases to weep and becomes dry. While no comparative figures are available, we have been impressed with the relatively smaller amounts of plasma required to restore the normal hematologic relationships in film-treated cases.

Third Degree Burns—In this series we confirm the impression of others that third degree burns are long in healing by any of the ordinary methods and to this sulfafilm is no exception when used as the sole definitive treatment. Thus, in 11 cases the average healing time was 44.2 days. Such burns involve necrosis, sloughing of tissue, infection and granulation, with healing either by spontaneous and slow epithelization or delayed grafting. It is commonly held that third degree burns often require 30 days to be prepared for grafting.

Recently we have used a test devised by one of us³ by means of which it is possible to determine at any time what area of a burn is second degree and what third degree. This consists of the injection of sodium fluorescein (10 cc. of 20 per cent solution) intravenously and the illumination of the area with ultraviolet light. When this is done the second degree areas stand out as brilliant yellow in color while those of third degree are dark purple.



A On admission



B On third day after admission



C On seventh day after admission



D Twelfth day—patient discharged

PLATE I—Case W. D. Patient was a 23 year old colored man who came in contact with a high tension wire and sustained a severe flash burn over 35 per cent of body surface (Berkow). The burn involved chest, face and neck, back and arms. Tannic acid spray was applied in the emergency room, consequently complete initial debridement was not possible until third day although film was used from the outset as definitive therapy. Patient's shock responded well to plasma therapy. He was out of bed on seventh day and discharged on twelfth day.

or black. Using such a test it is possible to excise third degree areas within a few days of their inception and by immediate grafting to shorten materially the time required for complete healing.

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PRIMARY HEMANGIOMATOUS TUMORS OF SKELETAL MUSCLE

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THE PURPOSE of this paper is to present a comprehensive survey of primary hemangiomatous tumors of skeletal muscle, with a complete analytic review of the literature to date. This is preceded by reports of two cases of our own, one most unusual and the other ordinary for comparison.

The main features of the first case are those not commonly encountered and are as follows. A 35-year-old woman noted over a period of five years, on the lateral aspect of her left thigh, a slowly growing mass which pulsated, had a bruit, and was unassociated with any symptoms except slight pain shortly before admission. Temporary ligation of the left common iliac artery was performed to minimize bleeding. A partially circumscribed hemangio-endothelioma, involving three contiguous muscles, was then widely excised. Postoperative deep roentgenotherapy was given. Complete recovery ensued, without any loss of function.

CASE REPORTS

Case 1—Y. D., white, female, age 35, was admitted to Doctor Shallow's private service at the Jefferson Medical College Hospital, September 21, 1942, referred by Dr. George Miller of Norristown, Pa. The chief complaint was a swelling in the left thigh.

In August, 1937, about three months after the delivery of her only child, the patient noticed that her left thigh, on the upper lateral aspect, was slightly larger than the opposite thigh. Doctor Miller, at that time, could find no demonstrable cause for the enlargement. During the next four years the disproportion increased gradually until a definite mass became visible. In December, 1941, on one occasion and for the first time, the patient experienced a dull diffuse pain in the left thigh and leg following exertion. A roentgenogram revealed no bony abnormality, and it was thought that the patient might have a "fatty tumor." In September, 1942, the patient again experienced the same type of pain as noted previously, and thereafter it persisted as a dull, nagging discomfort aggravated by exertion. Because of this symptom she again consulted Doctor Miller, who noted a distinct, pulsating mass for the first time.

Systemic review was normal except for the symptoms as elaborated pertaining to the mass. Her general health was excellent and her weight remained unchanged.

Past history, especially as regards previous trauma, revealed a fall on the ice in 1935 and a fall from a horse in 1936, with trivial injuries not related to the left hip. Her obstetrical record revealed the application of low forceps, with a resultant second degree incomplete vaginal tear, treated by primary repair. The puerperium was normal. An operation was performed in December, 1940, for removal of a stone from the right ureter. The family history was irrelevant.

Physical Examination—Temperature, pulse, respirations, and blood pressure were

normal. Weight 114 lbs. Except for a right inguinal operative scar the positive physical findings were confined to the upper lateral aspect of the left thigh. On inspection, there was present a large spindle-shaped mass extending from the anterior superior iliac spine to the junction of the upper and middle thirds of the left thigh, and about four inches at its maximum width. A few slightly dilated superficial veins were visible through the overlying skin which was freely movable over the mass. It was smooth, firm, difficultly compressible, nontender and slightly movable. An expansile pulsation was present throughout the entire mass, and over it a systolic bruit could be heard, loudest over the junction of the mass with the femoral artery. The main bruit could be silenced by compression of the femoral artery in the groin, which caused a slight decrease in the size of the mass. However in the upper left gluteal area there persisted a soft systolic murmur (Fig. 1). No thrill was palpable. Brianham's test was negative. There was no edema of the left leg and the pulsations of the popliteal, posterior tibial, and dorsalis pedis arteries were palpable and equal on both sides.

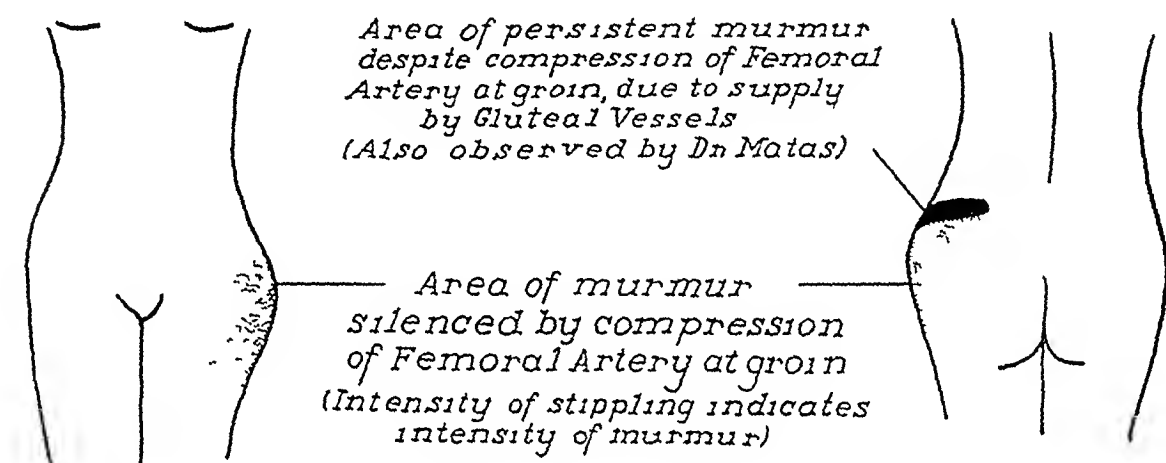


FIG. 1.—Diagram indicating distribution of murmur

Laboratory and Special Studies—The patient was studied at varying intervals during three hospital admissions. Blood count and uranalysis were normal. Wassermann and Kahn tests were negative. The electrocardiogram showed a conduction deformity suggestive of mild myocardial change. Roentgenograms of the lung fields and heart were essentially normal, and those of the left femur and hip were negative for bony abnormality or vascular calcification, but there was an alteration in the soft tissue structure detail in the area of clinical interest (Fig. 2). Arteriography by injection of thorotrast, both into the femoral artery and tumor mass itself, failed to outline the lesion satisfactorily.

The patient was seen in consultation by Dr. Rudolph Matas, who, following careful study of this case with repetition of many of the studies previously made, including arteriography, concluded that the lesion was a diffuse aneurysmal tumor, almost exclusively arterial, supplied largely by the femoral artery (probably 95 per cent) and the gluteals (barely 5 per cent). He believed that it could be designated as a progressive neoplastic nonmalignant angioma-arteriale cavernosum (not a cirroid in an arteriovenous sense).

In view of the type of lesion suspected preoperatively, both from our own studies and those of Doctor Matas, it was decided that primary extirpation was the procedure of choice. The patient well understood the risk involved and granted permission for a hip joint amputation, should this be necessary.

Operation—January 21, 1943. Doctor Shallow. Open-drop ether anesthesia. In order to minimize bleeding, the left common iliac artery was temporarily ligated by two turns of tape clamped with a hemostat retroperitoneally through an inguinal incision.

A longitudinal incision 11 inches in length was then made over the mass, starting at the level of the iliac crest. Within and beneath the tensor fasciae latae muscle, involving also the vastus lateralis and gluteus maximus, was a firm, rubbery, oval mass about 12 cm in length and 8 cm in width. It was densely adherent to the surrounding tissues rendering separation impossible except with the scalpel. Beginning at the lower pole each large vessel was exposed, clamped between clamps and ligated. The medial edge of the mass was then exposed, at which site the main supply was encountered. The



FIG 2—Roentgenogram of thigh (during arteriography) nine months after onset of pain, showing increased depth of soft tissue shadow lateral to greater trochanter.

vessel, representing the lateral femoral circumflex, was about the size of the normal femoral artery. In addition, there were numerous smaller collaterals. Since the common iliac artery was shut off by the tape, no thrill was felt, nor were any pulsating veins seen. The medial edge was freed to just below the iliac crest. Then the deep aspect of the mass was freed, at the posterolateral border of which several large blood vessels were encountered. These were divided between hemostats and the mass could then be turned upward. At the upper pole numerous large blood vessels were ligated and the mass then cut free near the anterior superior spine.

After removal of the tumor, many dilated blood vessels were noted on the sheaths of the gluteus maximus and tensor fasciae latae muscles. The fascia and muscles

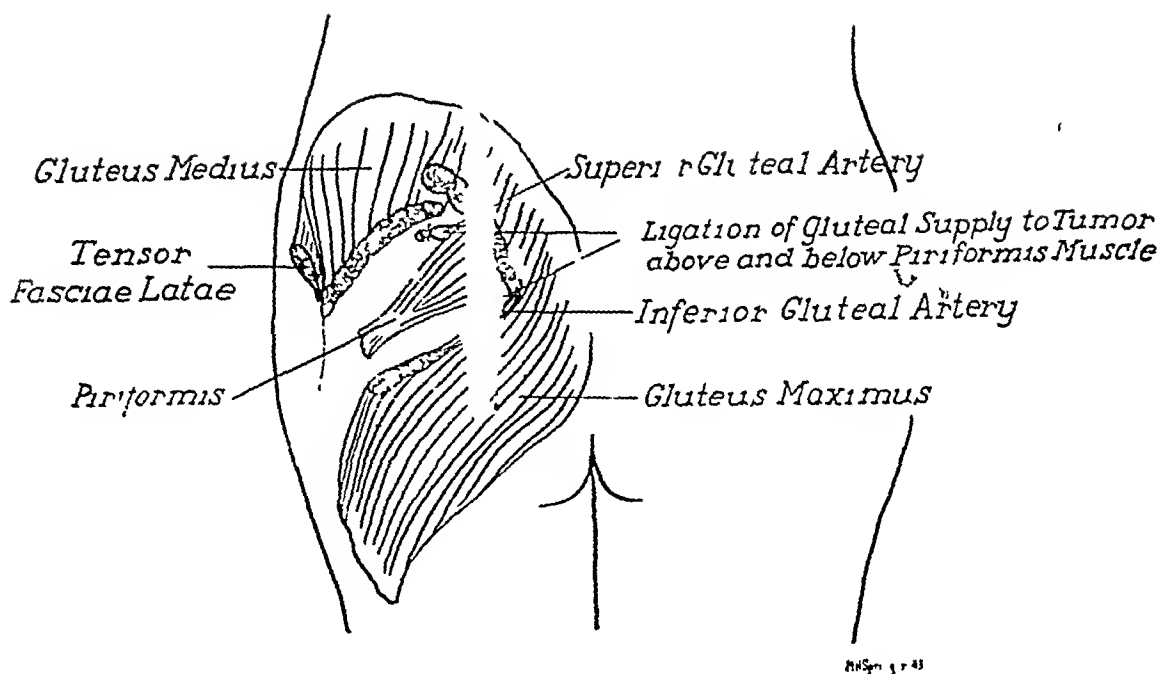


FIG. 3.—Sketch showing extent of excision of tumor and ligation of gluteal vessels above and below the piriformis muscle.

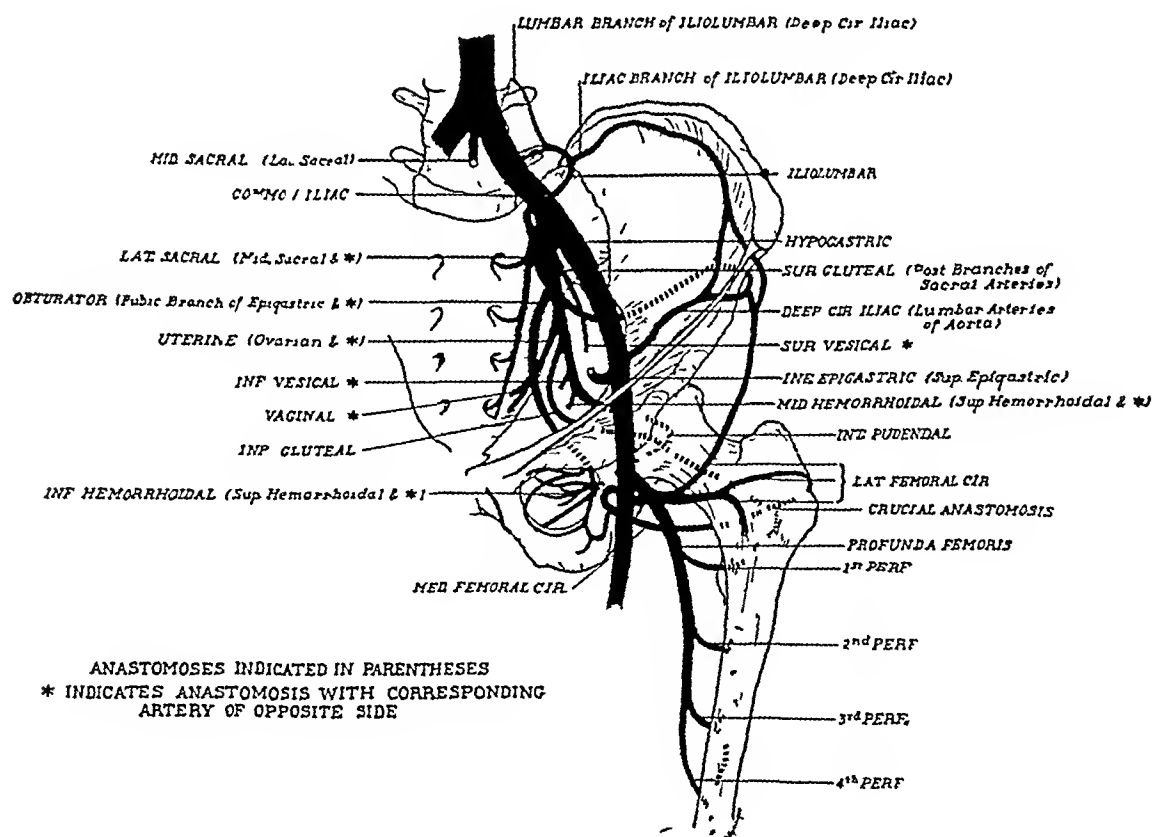


FIG 4—Diagram indicating collateral circulation following ligation of common iliac artery

containing the tumor were removed up to the upper pole of the cavity outlining the removed tumor mass. Here several large blood vessels were encountered leading posteriorly. These were followed through the gluteus maximus and medius muscles. Here they were divided (Fig 3) above and below the piriformis (superior and inferior) ischial foramina respectively and the muscle mass (tensor fasciae latae and part of the gluteus medius and medius) removed (Fig 7). Troublesome bleeding then occurred at the upper pole, even though the common iliac artery was shut off, due to collateral circulation (Fig 4). This was controlled by ligation of several large vessels.

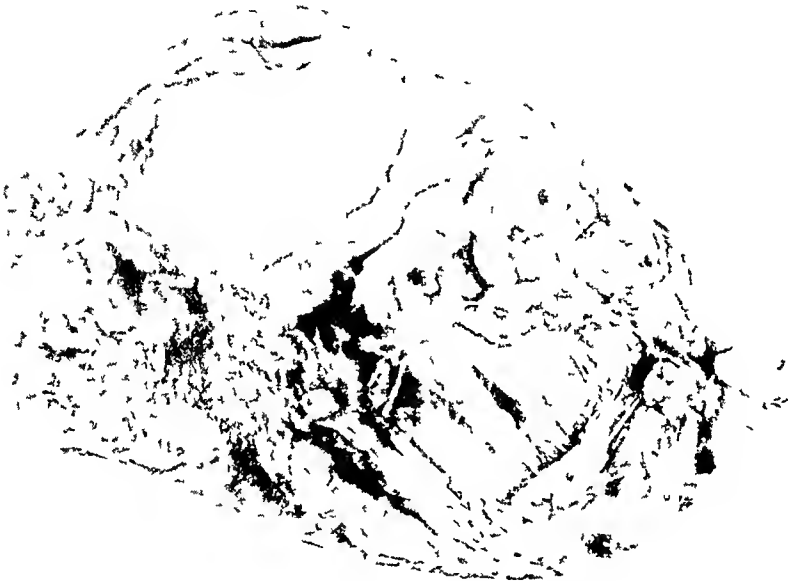
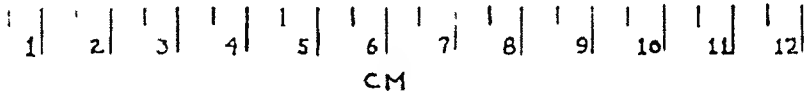


FIG 5—Gross specimen consisting of tumor and adjacent muscle

The tape around the common iliac artery was next removed, followed by bleeding from many capillary areas, readily controlled by continuous catgut sutures in the adjacent muscles. Sulfanilamide (8 Gm) was placed in the two incisions, both of which were closed without damage. Approximately 400 ties (80 tubes of catgut) were employed for ligation of the vessels. During the operation (total time exactly three hours) the patient received 16 Gm of plasma and 1200 cc of whole blood and remained in fair condition.

Pathologic Report—The specimen (Figs 5 and 6) consists of a partially circumscribed, fusiform, moderately firm mass, measuring 10 cm in length and 5 cm in diameter. It is composed of numerous bundles of muscle interspersed between which there are wide streaks of yellowish-gray tissue containing scattered large and small thin-walled blood vessels. The tumor is homogeneous throughout and contains no areas of necrosis or hemorrhage. The second specimen consists of two pieces of red muscle, the larger of which (Fig 7) measures 13 x 9 x 3 cm. They are not permeated with yellow tissue as in the first specimen and are covered with a fibrous tissue sheath about 1 mm thick, containing several dilated tortuous thin-walled blood vessels.

Microscopic examination shows many small caliber vascular channels in a fibrous and fatty tissue stroma, and degenerating muscle bundles at the periphery (Fig 8). In

other areas (Fig 9) there is very marked proliferation of the capillaries with hyperplasia of the lining endothelial cells. *Pathologic Diagnosis* Hemangioma, cavernous type.

Postoperative. —During the first six days the patient received 2,000 cc of whole blood and 45 Gm of plasma intravenously. There was no fever and red cell count gradually rose to normal levels, aided by high protein diet and

FIG 6

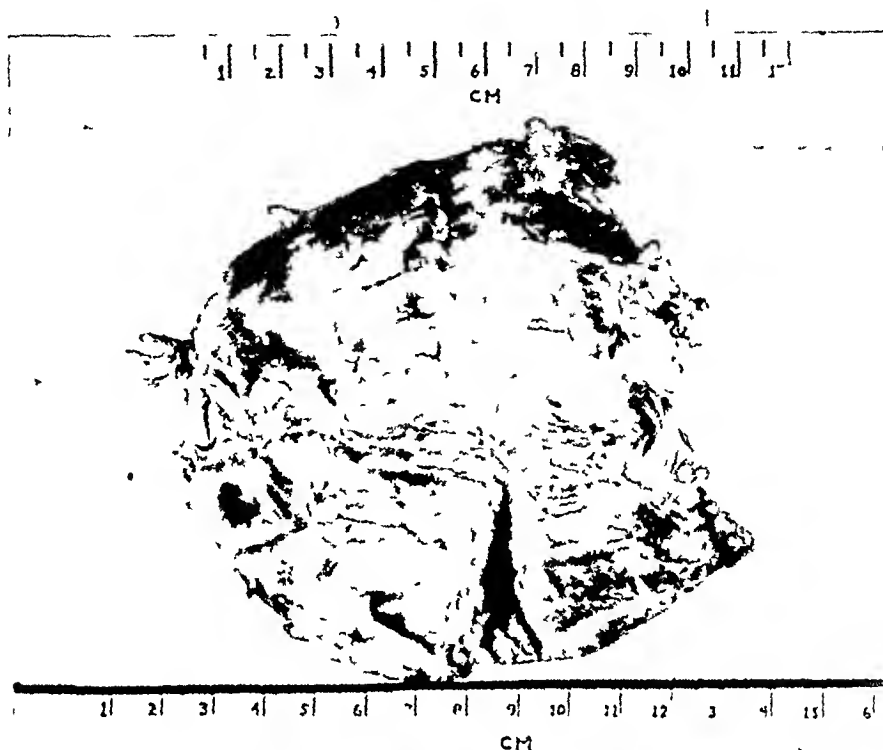


FIG 7

FIG 6 —Cut section showing replacement of muscle bundles by tumor tissue.
FIG 7 —Muscle mass adjacent to tumor containing dilated vessels of supply.

adequate doses of ferrous sulfate and vitamins B, C, and K. The inguinal incision healed by primary intention, but the thigh incision became infected and discharged small pieces of catgut and pus (positive for *Staphylococcus aureus*). Following irrigation therapy with sulfanilamide solution, the temperature became normal by the end

of the second week. At this time the patient was able voluntarily to flex the knee and thigh almost fully.

On the 35th day the patient was allowed out of bed, and by the 38th day could walk several steps unaided. At this time there was complete absence of the previous mass, pulsation, and bruit. Examination by Dr. David Kramer, from the Department of Peripheral Vascular Disease, revealed that the femoral pulses were fair on both sides and posterior tibial and dorsalis pedis pulses good on both feet. The oscillometric readings were 3° to $3\frac{1}{2}^{\circ}$ spikes in the thighs (normal 6° to 10°), $2\frac{1}{2}^{\circ}$ spikes in the legs on either side (normal 5° to 8°). The histamine test was somewhat delayed on the right side, but more definitely delayed on the left foot and leg as well as a slight delay in the thigh. The skin surface temperature readings were

	Right	Left
Big toe (dorsum)	24.5°	27°
Middle toe (dorsum)	23.3°	23.8°
Sole	26.8°	26.2°
Dorsum of foot	27.5°	28°
Leg	30°	30°
Thigh	20°	29°

These studies of circulatory function indicated some impaired circulation bilaterally, more so on the left, most likely due to arteriospasm.

The patient was discharged April 6, 1943, on the 75th day postoperatively. Because of the possibility of malignancy, as suggested by the histologic section, the operative field on the thigh was further treated by roentgen irradiation, given in doses of 200 r daily during a period of three weeks from June 20, to July 20, 1943. When last seen on January 20, 1944, one year after operation, the patient appeared in excellent general health, her gait was essentially normal, and the incisions were well healed.

The main features of the second case are those more commonly encountered, and are as follows. A ten-year-old boy noted on the inner aspect of his right arm following trauma, a lump which within six months increased in size and became painful. Physical examination revealed a soft, tender walnut-sized mass over which a bruit could be heard. A cavernous hemangioma involving the medial head of the triceps muscle was removed at operation. During the next two years a mass, representing recurrence in the long head of the triceps, gradually appeared on the posterior aspect of the arm, accompanied by pain and limitation of extension of the forearm. It was widely excised, followed by primary wound healing and complete restoration of function.

Case 2—V. S., white, male, age ten, was admitted to the Children's Ward, Jefferson Medical College Hospital April 4, 1941, with the chief complaint of a painful swelling on the inner aspect of the right arm. In October, 1940, the patient first noticed the lump following a blow. During the ensuing months the lump, which originally was pea-sized, increased gradually to the size of a walnut and was accompanied by a continuous, dull pain, aggravated by use of the arm. The past medical history and family history contributed nothing of significance.

Physical Examination—The vital readings were normal, and the positive physical findings were confined to the right arm. On the inner aspect at the middle third there was visible a mass about the size of a walnut, with normal overlying skin. It was soft, easily compressible, lobulated, and tender on palpation. No pulsation or thrill were felt, but a systolic bruit could be heard on auscultation. Branham's test was negative.

Laboratory Data—The blood count and urinalyses were normal. Wassermann and Kahn serologic studies were negative. Roentgenograms of the arm revealed no bony abnormality. Arteriography was unsatisfactory. *Diagnostic Impression*: Arteriovenous hemangioma or possible congenital arteriovenous aneurysm.

Operation—April 15, 1941. The first operation was performed under open drop ether anesthesia. A longitudinal incision about six inches long was made on the medial surface of the right arm, exposing an angiomatous mass involving the medial head of the triceps muscle. The main vessels of supply were from the profunda brachii, and these were ligated. About one-half of the body of the medial head of the triceps muscle, containing the mass, was resected. The fascia and skin were then closed without drainage. Pathologically, the lesion was reported as an angiomatous tumor of muscle.

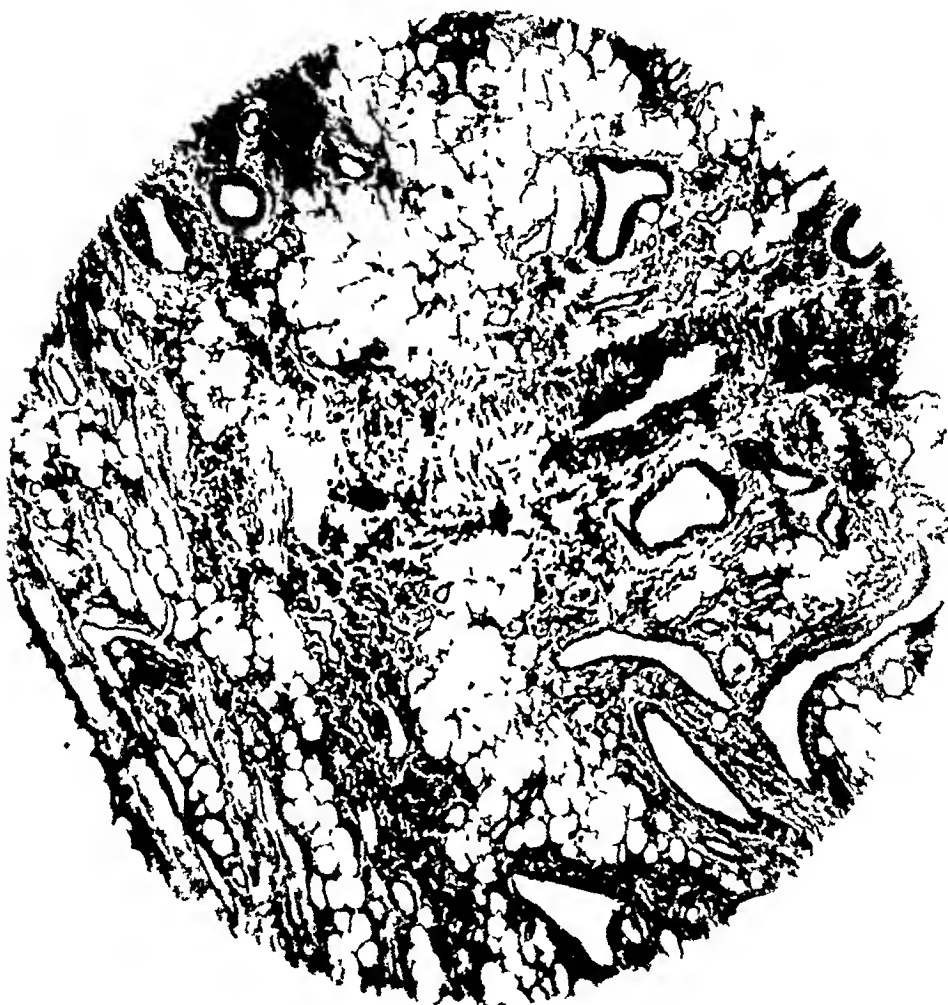


FIG. 8.—Photomicrograph ($\times 50$) showing vascular channels in a fibrous tissue stroma. Degenerating muscle fibers may be seen at the periphery.

Postoperative Course—The wound healed by primary intention, and the patient was discharged as well on April 28, 1941, the 13th day postoperatively.

Subsequent Progress—On March 10, 1942, a tender swelling posteriorly over the triceps muscle was noted. Biopsy revealed recurrence of the hemangioma.

Second Hospital Admission—The patient was readmitted on April 5, 1943, at which time his general physical condition was again good and the physical findings limited to the right arm. The old healed scar of the first operation was present on the inner aspect of the arm. On the posterior aspect in the lower third was a soft, lobulated,

well-defined, oval mass, about 1 x 2 inches in diameter, which was moderately tender on palpation. Again, the overlying skin, except for the recently healed biopsy scar, was normal. There was no pulsation, thrill, or murmur. Complete extension of the forearm was limited about 30° because of pain. Blood count and urinalysis were normal.

Second Operation—April 7, 1943. The patient was operated upon by Doctor Shallow, using nitrous oxide-ether anesthesia. A tourniquet was applied high on the arm. The incision was made over the mass and biopsy scar on the posterior aspect of

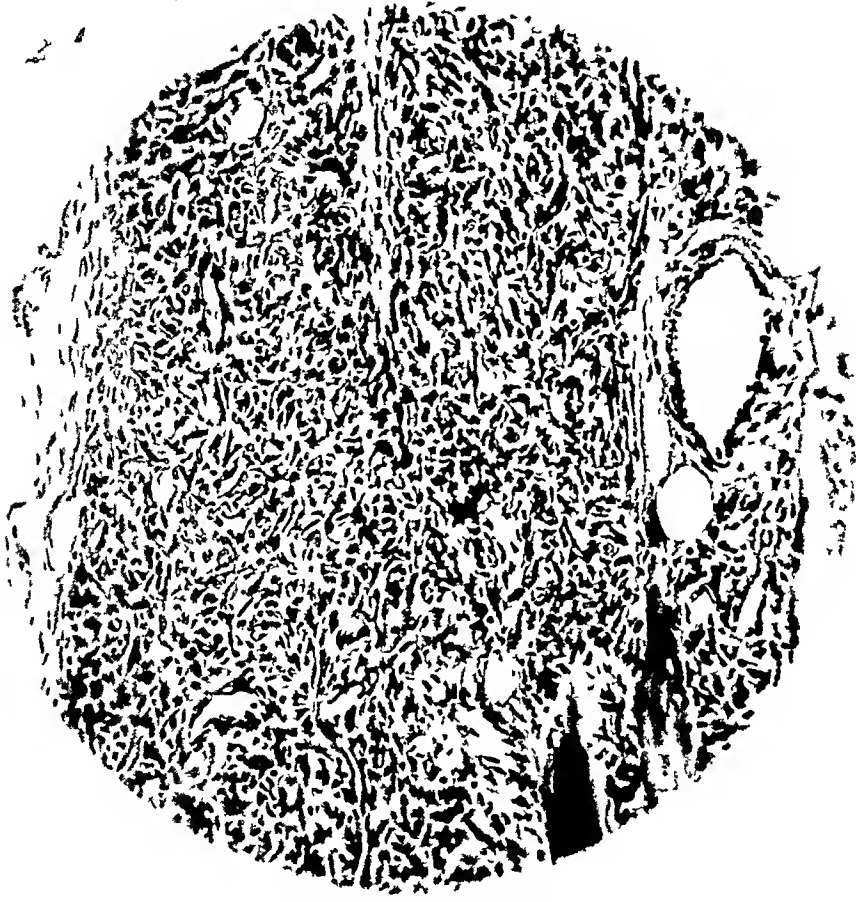


FIG 9.—Photomicrograph (x200) showing the endotheliomatous aspect of the lesion.

the arm so as to form an oval about 6 x 2 inches. There were no dilated vessels seen in the skin and subcutaneous tissue. Lying within the long head of the triceps muscle was an irregular, firm, infiltrating mass supplied by many moderate-sized dilated vessels. These vessels extended into part of the tendon of the triceps muscle, and several reached the capsule of the elbow joint. The entire mass and all the dilated vessels were removed (Fig 10). Most of the long head of the triceps muscle and part of the tendon were removed. Eight Gm of sulfanilamide were placed in the wound, which was then closed without drainage.

Pathologic Report—The gross specimen is shown in Figs 11 and 12. Microscopically, the section is made up of loose fibrous tissue in which there are numerous blood vessels. Some of the blood vessels are fairly thick-walled, while others consist of cavernous spaces. In some areas there are giant cells. These appear to be foreign body type and

are about necrotic material which appears to be bone. A representative area of the tumor is shown in Fig. 13. *Pathologic Diagnosis*—Hemangioma, cavernous type.

Postoperative Course—The wound healed by primary intention, and the patient was discharged on April 17, 1943, the 10th day postoperatively. On January 20, 1944,

FIG. 10

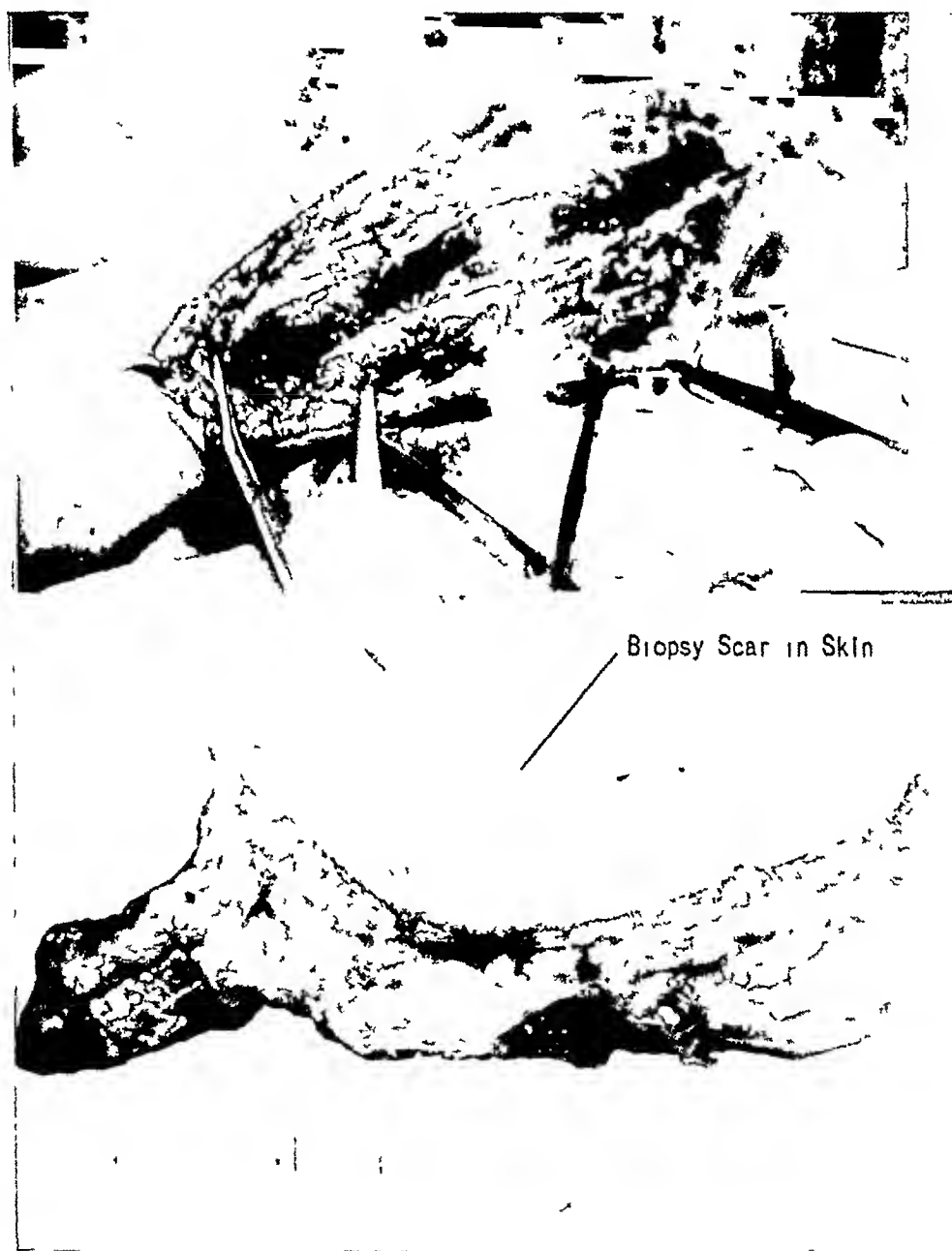


FIG. 11

FIG. 10—Tumor and adjacent muscle tissue excised widely.

FIG. 11—Specimen removed at operation.

when the patient was last seen, the scar was well healed, there was no evidence of recurrence, and extension of the forearm was complete, painless, and of essentially normal power.

For this study 335 cases of hemangiomatous tumors, primary in skeletal muscle, have been collected from the entire available literature, since the first reported case by Liston in 1843. Of this number, 191 were taken from

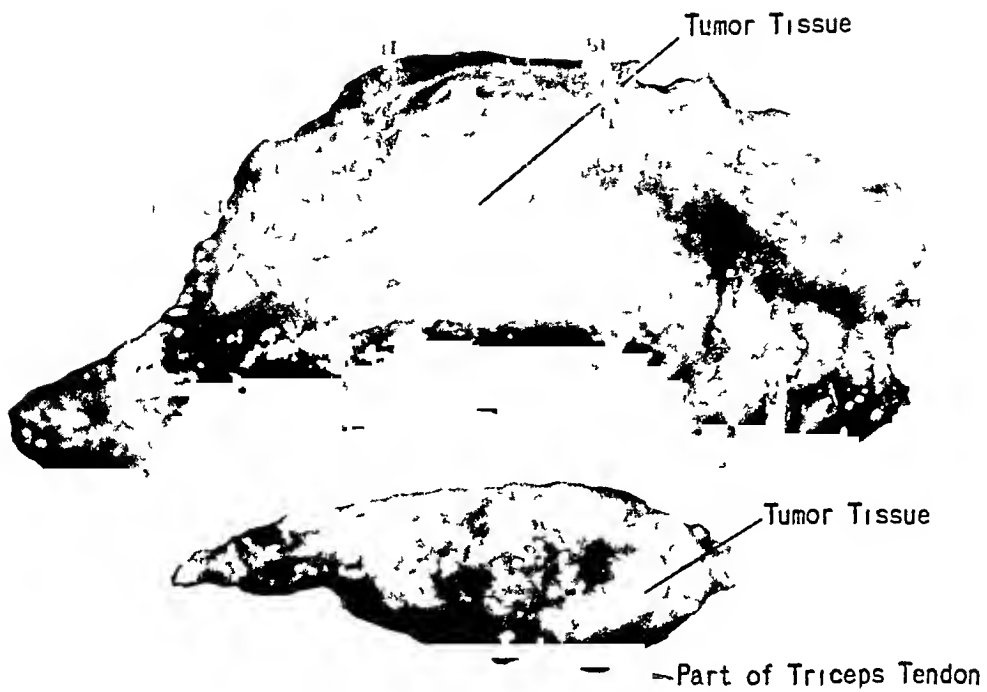


FIG 12 —Gross specimen on cut section

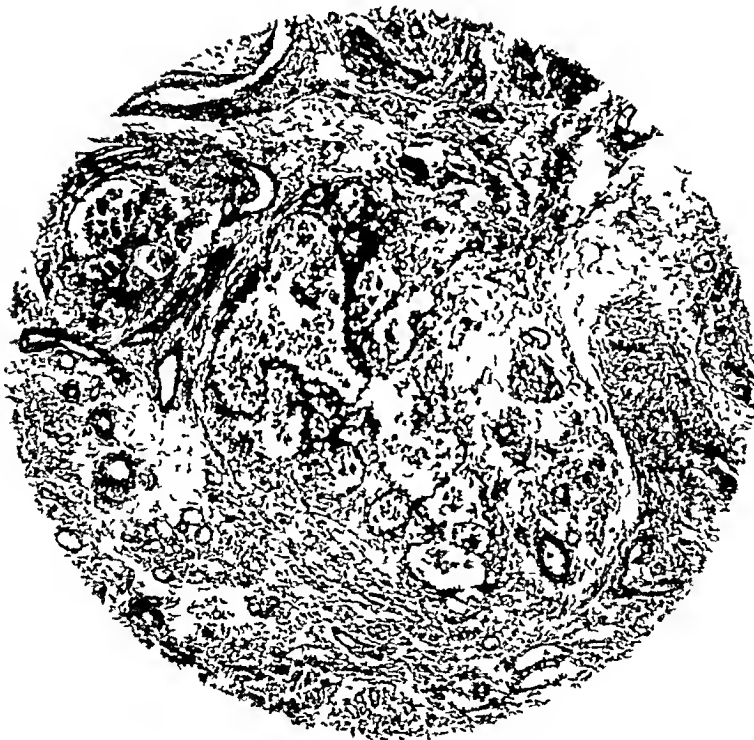


FIG 13 —Photomicrograph (x75) showing cavernous spaces in a loose fibrous tissue stroma

the review by Davis and Kitlowski in 1930. The 18 cases in the latter authors' series excluded by Jenkins and Delaney we have likewise excluded. In agreement with Weaver, we have, in addition, also excluded the first three cases of Eve since it appears probable that these were primary in the synovia of the knee joint capsule. All of the 62 cases, further collected by Jenkins and Delaney in 1932 we have included. Since that time we have been able to collect 80 additional cases from the world literature plus two of our own, summarized in Table IX.

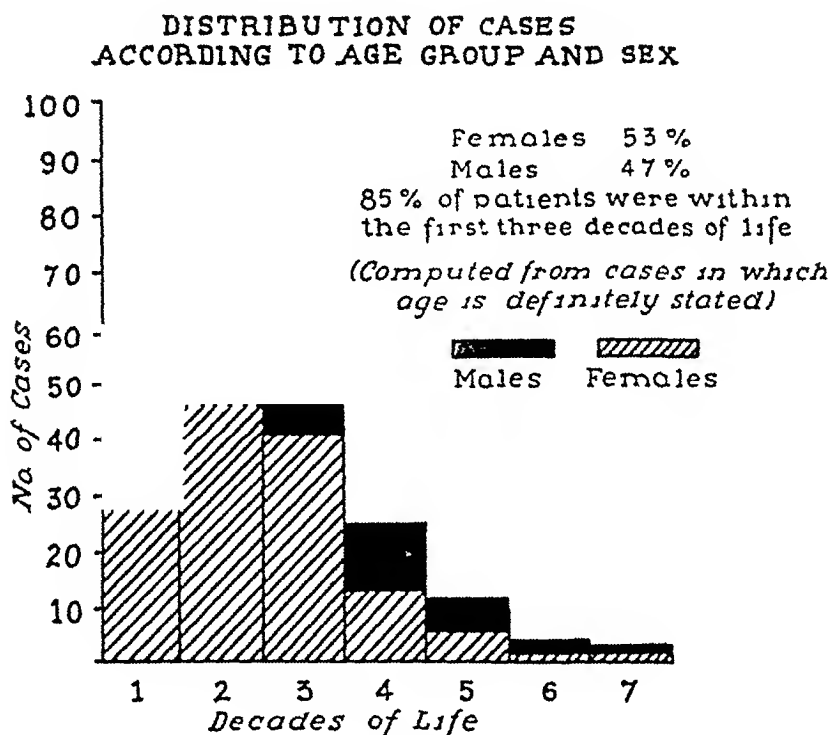


CHART I
Age and sex incidence

The most complete reviews of this subject in the past are those of Sutter (1905), Davis (1908), Colli (1913), Mondor and Huet (1923), Davis and Kitlowski (1930), and Jenkins and Delaney (1932).

CLASSIFICATION

Hemangiomatous tumors comprise all those originating from blood vessels and their various components. Oughterson and Tennant classify these under three main divisions. The first group, or hemangiomas, consists of hemangiomatous malformations and hemangioblastomas. The second group is represented by angiomyoneuromas or glomus tumors, and the third group by Kaposi's hemorrhagic skin sarcoma. For the hemangioma group various authors have proposed classifications (Table I), but to date no single one has been universally accepted by both clinician and pathologist. In the present review, Muscatello's classification of hemangiomas has been adopted, because the greatest number of the pathologic reports fit conveniently into it. Further-

more, it is more differentiating than that of Boyd, Matas, and Fraser, and is more applicable to this study than that of Watson and McCarthy

INCIDENCE

According to Kornmann, hemangiomas comprise 2-3 per cent of all tumors in the body and 7 per cent of all benign tumors. In a series of 1,308 hemangiomas (Watson and McCarthy), ten, or 0.8 per cent, occurred in skeletal muscle. In the present series the disease is entirely confined to the white race, except for seven Japanese (2.1 per cent) and three Negroes (0.9 per cent). Sex incidence is about equally divided, and the disease occurs predominantly (85 per cent) within the first three decades (Chart I).

Thomas has reported a case in which there were two tumors of the vastus internus muscle which had a histologic picture similar to that of a glomus tumor. The author, however, was not certain that these represented true glomus tumors. In our review of this case we concur with Light, who doubts the correctness of the diagnosis. Since glomus tumors in practically all instances arise in the stratum reticulare of the corium, and since to date there are no authentic cases arising primarily in skeletal muscle, this group of hemangiomatous tumors will not be further discussed. Kaposi's sarcoma is likewise omitted, since the lesions are not primary in skeletal muscle but originate in the derma.

TABLE I

CLASSIFICATION OF HEMANGIOMAS BY VARIOUS AUTHORS

Author Classification	General Classification of Hemangiomas					Watson & McCarthy
	Boyd	Matas	Fraser	Muscatello		
	1 Capillary	1 Capillary	1 Capillary	1 Capillary		1 Capillary
	2 Cavernous	2 Cavernous	2 Cavernous	2 Cavernous		2 Cavernous
		3 Plexiform	3 Compact	3 Venous		3 Angioblastic
				4 Arterial		4 Racemose
						5 Diffuse
						Systemic
						6 Metastasizing
						7 Nevus vinosus
						8 Hereditary
						Hemorrhagic
						Telangiectasis

ETIOLOGY AND PATHOGENESIS

To date there is no universal agreement concerning the etiology and pathogenesis of hemangiomas, and the following represent the various theories. The prevailing one is that hemangiomas are congenital tumors. As such their origin may be from abnormal embryonic sequestrations of vascular tissue which do not fit into the ordinary circulatory system and retain their embryonal characteristics (Cohnheim, Ribbert, Fraser, Ewing, Watson). Other views are that they may result from disease of the vasa vasorum (Virchow), simple

hypertrophy of vascular elements and not as a new growth (Rokitansky), obstruction to blood flow (Sutter), increased vascular tension in the area of formation of the tumor (Monzardo, Thomas), loss of support to small vessels by atrophy of the surrounding connective tissue (Pupovac), or they may represent vascular fibromas (Honsell). Heredity apparently plays no role since no two cases appeared in the same family.

A few authors (Pilzer, Lowenthal, Maier) believe that trauma is a primary factor. On the other hand, most authors agree that trauma plays an important secondary role, both in the growth of the tumor and the development of symptoms. In the present series trauma was reported as related to the onset of the symptoms and signs in 17 per cent of the cases (Table VII). The trauma may be external or internal (muscle action), or a combination of both. In some instances the tumor was symptomless for years, but became painful after a major injury or a series of minor ones.

Another factor playing a secondary role in inciting or aggravating symptoms, as stressed by Weaver, is the presence of systemic infection, as scarlet fever (Kidner, Case 2), diphtheria (Weaver, Case 4), grippe (Guyot and Jeanneney), appendicitis (Davis and Kitlowski, Case 6), pneumonia (Ogata and Yazaki) and the common cold (Fulton and Sosman, Case 1).

PATHOLOGY

Primary hemangiomas of skeletal muscle arise in the vascular plexus of the muscle or in the perimysium between the muscle fibers. They represent a dilatation and overgrowth of neoplastic vessels, as a rule benign in nature, but which may at times assume malignant qualities. They differ from the dilatations seen in varicose veins and the overgrowths in granulation tissue and highly vascular tumors in that the latter represent the responses of otherwise normal vessels to disease or to an increased demand for greater local blood supply. When the demand ceases the vessels again may assume normal size.

Grossly, the specimen often resembles a muscle containing varicose veins. The color may be bluish due to thin-walled cavernous spaces protruding between the muscle fibers. In some cases the color is reddish, yellowish, gray, or a combination of these. The mass is usually moderately compressible, soft, and spongy, but may be relatively hard and firm, as in the authors' Case 1. On cut-section, whitish septa of fibrous tissue and remnants of tissue in which the tumor developed bound communicating blood spaces. In some cases the vessels may stand out like stems (Fig. 6). Muscle fibers are usually entirely replaced by the tumor tissue especially at the center, but may be present in various stages of degeneration peripherally. The hemangioma may be sharply differentiated from the surrounding muscle or may gradually merge into it. Thus pathologico-anatomically one may refer to circumscribed, partially circumscribed, and diffuse types (Table II).

The circumscribed type was reported in 45 cases, or 13 per cent of the series. When this type possesses a distinct capsule (approximately half the cases), it seldom involves any structure other than the muscle itself, although in two cases the lesion was adherent to the periosteum and in two others nerves were damaged.

In the partially circumscribed type (16 cases or 5 per cent), part of the tumor infiltrates the muscle and the remainder is distinctly separate, sometimes with a definite fibrous capsule. In three of these cases the tumor was adherent to the periosteum.

The diffuse type was by far the most frequent (131 cases, or 39 per cent). In the remaining 143 cases (43 per cent) the gross pathologic type was not mentioned. In the diffuse type there is an infiltration in irregular fashion of part or all of one muscle or adjacent muscles and other tissues with no sharp line of demarcation. Thus nerves were involved in 18 cases, subcutaneous tissue in ten, skin in three, periosteum and bone in 11, synovial membrane in seven, large arteries in six, and large veins in three.

Microscopically, the tumor consists of vascular elements (cavernous, capillary, venous, or arterial) in a connective tissue stroma (Table II). The predominating variety is the cavernous, although seldom do pure types exist. It is characterized by large irregularly-shaped spaces filled with normal blood in a fibrous tissue stroma. The blood spaces usually have an endothelial lining but lack the definite walls of normal blood vessels. They communicate freely with each other and receive nutrition by means of their own arteries which empty into dilated veins. When large arteries are present, the satellite veins are often absent or else scarce. Mixed tumors may also develop in combination with fatty tissue (Keller), nonstriated muscle (Hounsell) or lymph channels (Monzardo, Ritschl, Lucke).

The supportive tissue varies greatly in amount, thus determining the consistency of the tumor. Thrombosis, sclerosis, and hyalinization of dilated vessels may occur, followed by organization and laying down of dense masses of fibrous tissue. Fibroblastic proliferation may be so marked as to permit the diagnosis of sarcoma to be considered. In the stroma one finds remnants of striated muscle in various stages of degeneration. In the central part of the tumor the degenerative changes are complete, while towards the periphery the fibers are better preserved. Inflammatory changes are sometimes observed in the form of round cell infiltration or even at times as suppurating processes as a result of exogenous infection through injury. Rarely one may find ossified areas (Margarucci, Case 1, Kolaczek, Roche and Uzac, authors' Case 2).

Blood calculi or phleboliths, varying in size from less than a millimeter to half a centimeter, may form at the periphery of the tumor where stasis is most marked. They consist of organized thrombi infiltrated with tricalcium phosphate, invested in a bed of endothelial cells and adherent to the vascular wall.

A cirsoid aneurysm may result from the development of free connections between the angioma and the arterial side of the circulation. When the angioma is freely connected with the venous side through veins with defective valves it is affected by mechanical changes in pressure.

Hemangiomas of muscle frequently remain inactive for long periods of time and then begin to extend rapidly with an invasiveness suggestive of malignancy. Growth is not by expansion as is usual in benign tumors, but by infiltration. The hemangioma invades the adjacent muscle fibers by multicentric proliferation of endothelial cells which subsequently form channels through which blood flows. The newly formed vessels and their supportive tissues compress the invaded muscle and its blood supply, resulting in atrophy and gradual replacement. This process becomes limited in the encapsulated circumscribed type. There is practically no tendency of the neoplastic vessels to anastomose with those already present in the invaded tissue. Indeed, the larger blood vessels may even be invaded, as in Case 2 of Kidner in which no posterior tibial artery could be found. In parts the tumor may be very cellular, as in the authors' first case (Fig 9), and distinct vessels very scarce or not recognizable. Nerve fibers, when present, are usually resistant and appear normal microscopically, but the interior of a nerve trunk may become infiltrated (median nerve in the case of Huard). Bone may be affected secondarily by pressure of the adjacent tumor, resulting in atrophy, by increased blood supply, resulting in hypertrophy, and by irritation, resulting in periosteal proliferation.

The peculiarity of infiltration by a benign tumor, as just described, raises the question as to whether these tumors of muscle should be considered as potentially malignant, and whether metastases occur. Speaking of hemangiomas for all tissues of the body, Geschickter and Keasbey state that "an occasional angioma may metastasize following trauma or after repeated recurrences, but less than 1 per cent of benign angiomas subjected to treatment fall into this group." Malignant vascular tumors have recently been excellently reviewed by Stout. According to this author, hemangioendothelioma is the most common type, characterized by the formation of atypical endothelial cells in greater numbers than required to line the vessels with a simple endothelial membrane, and the formation of vascular tubes with a delicate framework of reticulin fibers, showing a marked tendency for the lumens to anastomose. Silver staining of the vascular reticulin sheath causes the tubes to stand out in distinct relief. Stout has observed two cases* in which the tumor was primary in skeletal muscle. In one of them he reports the occurrence of evidence of lung metastases and symptoms of paraplegia four months after operation and death after seven months. Other authors have reported cases in which the tumor, histologically, has been regarded as

* These cases appeared in the literature after the statistics for this article had been completed.

suggestively or actually, malignant (Teller, Solis-Cohen, and Levine, Rives and Bañas, Mauio, authors' Case 1)

TABLE II

INCIDENCE OF THE VARIOUS GROSS AND MICROSCOPIC PATHOLOGIC TYPES

Gross	Pathologic Types		Microscopic		
	No	Per Cent		No	Per Cent
Diffuse	131	39%	Cavernous	182	54%
Partially circumscribed	16	5%	Capillary	11	3%
Circumscribed	45	13%	Arterial	8	2%
Not stated	143	13%	Venous	8	2%
			Mixed and unclassified	126	38%
Total	335			335	

SYMPTOMS, SIGNS AND SPECIAL STUDIES

Hemangiomas of muscle may be present for years, often from birth, without giving rise to symptoms of sufficient severity to cause the patient to seek medical aid. The duration of symptoms varied within the wide limits of one to 70 years, but was usually one to five years.

Pain is the cardinal symptom. It was definitely present in 200 cases (60 per cent), absent in 47 (14 per cent), and not stated in 88 (26 per cent). As emphasized by Weaver, there is no other small benign tumor which can be so excruciatingly painful as a hemangioma, except for the glomus tumor of Masson, which is somewhat similar in nature. Those located in long narrow muscles give rise to pain more frequently, since the spread usually exerts pressure on some nerve branch. On the other hand, wide flat muscles provide greater room for expansion before pressure on sensory nerves occurs. Congestion within the tumor as a result of trauma, obstruction by phlebolith formation, and growth within resistant surrounding tissues may be a significant secondary factor in the production of pain. Absorption of toxins from a distant focus might possibly explain those cases in which pain followed a previous infection.

The pain may vary from a dull ache and feeling of fullness, due to distention of the blood spaces, to a sharp radiating root-type of pain, often accompanied by protective muscle spasm, as a result of pressure on nerves from without or by inclusion of nerve elements in the tumor. It may be present only during the contraction phase, when muscle thickening causes nerve pressure (Mondor and Huet, Diedoff). There may be marked sensitiveness to touch (Kirmisson) and paresthesias such as numbness or formication.

A mass was present in 329 cases (98 per cent) and absent in six (2 per cent). It may be sharply demarcated or ill-defined and vary in size from a pea when first noticed (Seifaty, authors' Case 2) to a small pumpkin (Fitzsche) or fetal head (Honsell). It was described as tender in 105 cases (31 per cent), soft in 83 (25 per cent), hard in 68 (20 per cent),

HEMANGIOMATA OF MUSCLE

fuctuant in 23 (7 per cent), pseudofluctuant in 10 (3 per cent), elastic in 37 (11 per cent), and reducible in 26 (8 per cent)

In ten cases (3 per cent) pulsation was noted, expansile in four (12 per cent), with a thrill in two (6 per cent) and a bruit in six (18 per cent)

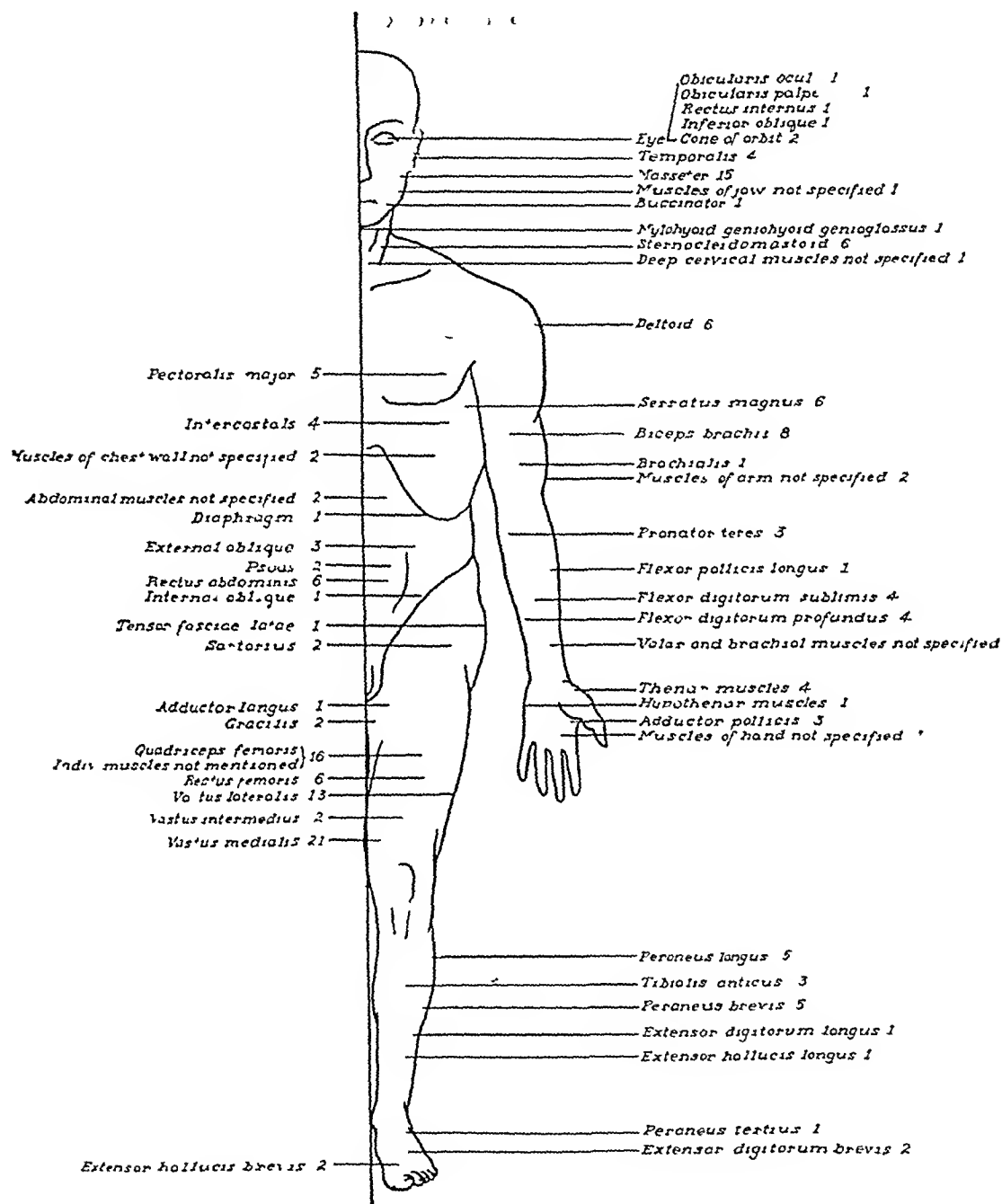


CHART II
Incidence in individual muscles

The presence of a pulsation may be accounted for by several factors. In the first place, it may merely represent a transmitted pulsation from a neighboring large artery. Second, it may represent the pulsation of an abundant arterial supply, for it is well known that very vascular tumors, as for example certain sarcomas, may pulsate. Hemangiomas are unique among tumors in that the tumor itself is composed of neoplastic vascular

elements which receive nutrition for growth from ordinary blood vessels, thus constituting two systems, one neoplastic, the other essentially normal. It is the belief of the authors that the pulsation of the tumor present in the first case was in the large arteries of supply from the deep femoral and gluteal vessels. The abundance of these vessels may be ascribed to the

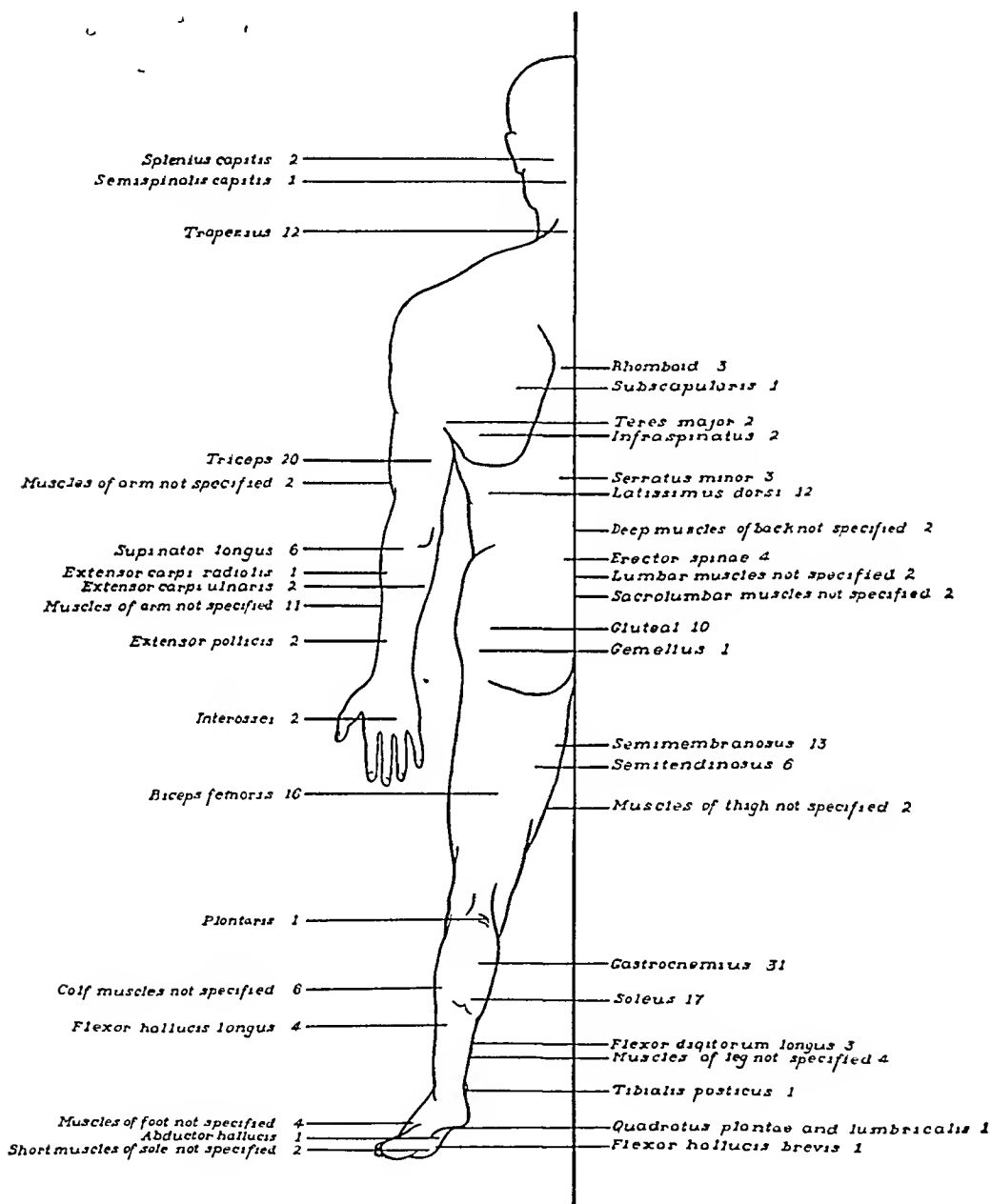


CHART III
Incidence in individual muscles

increased local demand for blood supply to a large, growing, unusually cellular hemangioma. The dilatation and hypertrophy of these vessels noted at operation may possibly be accounted for by the increased resistance to inflow of blood by the dense compressing fibrous tissue stroma. Third, the pulsation

may be from the neoplastic vessels themselves as in arterial angiomas sometimes referred to as racemose, plexiform or arteriovenous hemangiomas (Picardi, Matsunami, Case 1, Serra, Lavenia, and Fiebig)

In 22 cases (66 per cent) the tumor could be reduced in size by elevating the part. Increase in size or firmness was noted in 20 (66 per cent) on lowering the part or obstructing the venous return.

The overlying skin is usually normal, and was definitely stated as such in 132 cases (39 per cent). It was freely movable in 55 cases and fixed in seven. The skin was somewhat bluish over the tumor in 13 cases, telangiectatic in seven, contained dilated veins in ten, was atrophic in one, ulcerated in six, and contained naevi in two.

The area of predilection is the muscles of the extremities, particularly the lower (Table III), but any situated muscle in the body may become involved (Charts II and III). The thigh, especially the quadriceps femoris muscle, represented the most frequent site. The tumor usually involved only one muscle (66 per cent), but up to five or an entire group were recorded (Table IV). In five cases the tumors were multiple, that is involved non-contiguous muscles (Lichtenauer, Reboul, Poucel, Porcile, and Oi and Yazaki).

TABLE III
INCIDENCE AT VARIOUS SITES

Location*	No	%
Head	26	7.7%
Neck	10	3.0%
Trunk	63	18.8%
Chest	39	11.6%
Diaphragm	1	0.3%
Abdomen	12	3.6%
Back	11	3.3%
Upper extremity	87	26.0%
Shoulder	9	2.7%
Arm	30	9.0%
Forearm	38	11.3%
Hand	10	3.0%
Lower extremity	148	44.2%
Buttock	7	2.1%
Thigh	73	21.8%
Leg	60	17.9%
Foot	8	2.4%
Not stated	1	0.3%
Total	335	

* Cases are listed for site of most extensive involvement

TABLE IV
NUMBER OF MUSCLES INVOLVED

Involvement of Muscles	No	%
One muscle	221	66.0%
Two muscles	42	12.5%
Three muscles	12	3.6%
Four muscles	4	1.2%
Five muscles	0	0.3%
Group (not specified)	55	16.4%
Total	335	
Multiple Tumors		
In 3 cases 2 separate muscles		
In 2 cases 3 separate muscles		

A deformity was present in 86 cases (26 per cent), represented by increased diameter of an involved limb in 16, increased length of the limb in three, contracture or atrophy in 25, pes equinus in 21, exophthalmos in two, and other deformities in 9.

Impairment of function was observed in 84 cases (25 per cent). In 32 limitation of motion, varying in degree from slight to total incapacity of the part, was noted, and limitation because of pain in an additional 20. Weakness of an involved extremity was reported in six, due to replacement of muscle tissue or the large size of the tumor mechanically preventing a group of muscles from contracting normally. In 26 a limp was present.

Exploratory puncture was performed in 39 cases, yielding blood in all but one, and is a valuable aid in establishing the correct diagnosis.

Roentgenologic studies were made in 30 per cent of the cases. The most important finding is the presence of phleboliths in areas of the body in which there are normally no large plexuses of veins, thus indicating an abnormal collection of vascular channels, usually a hemangioma. Phleboliths are characterized roentgenographically as densely calcified, round or slightly oval, smoothly outlined areas, usually multiple, often exhibiting concentric laminations. They were present in 49 cases and absent in 51. Calcified parasites may rarely be confused with phleboliths. Trichinosis parasites are too small to appear except in excised muscle specimens. Cysticerci may become calcified but are not as dense, lack lamination in structure, are rarely present in groups, and are finely granular. Lymph nodes, tubercles, infarcts, chronic abscesses, fibroids, dermoids, hydatid cysts, or arteries may become calcified but differ from phleboliths in size, shape, and distribution. Myositis ossificans is recognized by its irregular streaky distribution.

A soft-tissue mass was noted in eight cases, and calcification of part of the tumor also in eight. Changes noted in the adjacent bone were a periosteal reaction in six, hypertrophy in one, eburnation in one, atrophy in two, and pressure erosion in one.

Angiography frequently permits visualization roentgenographically of hemangiomas, particularly those of the venous type, and is of value in determining the size, extent, and relationship to surrounding large vessels. It has also been employed to evaluate the results of treatment by sclerosing agents or deep roentgenotherapy. Venography is applicable to those cases in which the angioma is so situated that a tourniquet can be placed proximally to prevent rapid dispersion into the general circulation. The radiopaque material may be injected into a nearby vein or into the tumor itself. Arteriography is applicable to the arterial or arteriovenous type.

DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The diagnosis of hemangioma of muscle is difficult mainly because of the comparative rarity of the lesion and the depth of the tumor. However, the diagnostic features enumerated in Table V should enable one to make the

correct diagnosis in most cases if the existence of the lesion is kept in mind. Angiography is being employed with greater frequency and with increasing success as an adjunct in diagnosis.

TABLE V
INCIDENCE OF THE VARIOUS SALIENT DIAGNOSTIC FEATURES

Diagnostic Features	Present		Absent		Not Stated	
	No	%	No	%	No	%
1 Age within first three decades	241	72%	44	13%	50	15%
2 History of trauma	57	17%	31	9%	247	74%
3 Mass or enlargement	329	98%	6	2%		
4 Pain	200	60%	47	14%	88	26%
5 Deformity	86	26%	31	9%	218	65%
6 Functional impairment	84	25%	35	11%	216	64%
7 Blood on aspiration of tumor	38	11%	1	0.3%	296	88%
8 Phleboliths on roentgen ray	49	15%	51	15%	235	70%

The diagnosis was correctly made in 19 per cent of the cases and mentioned as an alternative diagnostic possibility in an additional 3 per cent (Table VI). Among the miscellaneous incorrect and alternative diagnoses not mentioned in the table were acute abscess, arthritis, synovitis, bursitis, myositis, myositis ossificans, osteomyelitis, phlebitis, pelvic cellulitis, syphilis (gumma and tenosynovitis), tuberculosis (of muscle, lymph, nodes, or bone), hematoma, varix, arteriovenous aneurysm, clubfoot, foreign body, hernia (epigastric, paraumbilical, and pulmonic), pseudo-elephantiasis, ossifying tumor, ganglion, bone tumor, hygroma, and malignant neoplasm.

TABLE VI
DIAGNOSES MOST COMMONLY MADE
Preoperative Diagnosis in 335 Cases

Preoperative Diagnosis	Definite		Alternative	
	No	%	No	%
1 Angioma	65	19.4%	11	3.3%
Angioma of muscle	35	10.4%	4	1.2%
Angioma (tissue not stated)	24	7.2%	7	2.1%
Angiofibroma	1	0.3%		
Angiolipoma	1	0.3%		
Angiolymphoma	4	1.2%		
2 Miscellaneous incorrect diagnoses	37	11.0%	12	3.6%
3 Lipoma	19	5.7%	4	1.2%
4 Cyst (including dermoid)	10	3.0%	6	1.8%
5 Fibroma neurofibroma, neuroma	10	3.0%	1	0.3%
6 Sarcoma	8	2.4%	6	1.8%
7 Abscess (chronic)	6	1.8%	3	0.9%
8 Aneurysm	5	1.5%	1	0.3%
9 Benign neoplasm	4	1.2%	2	0.6%
10 Myoma	3	0.9%	1	0.3%
Diagnoses made (correct or incorrect)	167	49.9%	47	14.0%
None stated	168	50.1%		
Total cases	335			

The clinical differentiation of hemangiomas of muscle from other benign neoplasms is not always easy, and in the case of small growths it may be necessary to examine the specimen microscopically before a final diagnosis can be made. Among this group a hemangioma is most frequently mistaken

TABLE VII
PATHOLOGIC CLINICAL AND LABORATORY FEATURES IN THE DIFFERENTIAL DIAGNOSIS OF HEMANGIOMAS
OF STRIATED MUSCLE AND ANEURYSMS

Features	Hemangioma		Cirsoid Aneurysm		Arteriovenous Aneurysm		Simple Aneurysm	
	(Capillary Cavernous Venous)	(Arterial Hemangioma)						
Pathologic Origin (Etiology)	Neoplastic	Controversial Neoplastic congenital, traumatic			Congenital or traumatic	Infectious (luetic) degenerative traumatic		
Types	Capillary cavernous, venous (Usually mixed)	Arterial hemangioma			Aneurysmal varix Varicose aneurysm	Fusiform Saccular With other arteries		
Communications	With vessels of similar type	Multiple A-V communications usually of similar vessels			A-V communication, usually single involving the larger peripheral vessels			
Site	None	None			Absent in aneurysmal varix Present in varicose aneurysm	Present		
Clinical								
Characteristic age group	First three decades 85%	Young adult life			Any age	Middle age or later		
Common location	Lower extremity 44% Upper extremity 26% Trunk 19% Head 8% Neck 1%	Scalp face hands feet			Scarpa's triangle popliteal space axilla cubital space neck	Aorta Large peripheral vessels		
Rapidity of enlargement	Slowly	Slowly Sometimes rapidly, following trauma			Varies	Slowly		
Pulsation	Absent except in 2 1% Expansile in 1 2%	Usually present and expansile			Usually present and expansile	Usually present and interrupted		
Thrill	Absent except in 0 6%	Often present continuous type			Usually present continuous type (most distinct over communication)	Usually present interrupted type		
Murmur	Absent except in 1 8%	Often present continuous type			Usually present, continuous type	Usually present interrupted type		
Surface temperature of overlying skin	Usually normal	Usually increased			Usually increased in vicinity of aneurysm, but decreased distally	Usually normal		
Veins of overlying skin	Usually normal Dilated in 3%	Usually prominent May pulsate			Usually prominent	Usually normal		
Arterial pulsation distal to lesion	Normal	Sometimes diminished			Usually diminished	Usually diminished		

* Markedly increased in author's case 1

for a lipoma because of its lobulation, softness, and compressibility. Changes in size and consistency with change of posture, and aspiration of blood on exploratory puncture should rule out lipoma. Fibromas and neurofibromas as a rule are very firm, usually sharply demarcated from the surrounding tissues, and grow more rapidly than hemangiomas. A hemangioma with a dense fibrous tissue stroma would be difficult to distinguish clinically from these tumors, but aspiration of blood from the tumor should again be of aid in differentiation.

Because of its smooth contour and occasional pseudofluctuation, a hemangioma of muscle may resemble a cyst. Careful examination will usually reveal that the mass is in the muscle, thus eliminating dermoid cysts which are not found in the voluntary muscles of the extremities. Hydatid cysts yield yellow fluid on puncture, rather than blood, in which characteristic hooklets may be found. The Casati intradermal reaction which is both rapid and specific for echinococcosis may also be employed.

Primary sarcoma of the muscle itself is exceptionally rare, but sarcoma arising in the intermuscular connective tissue represents a definite diagnostic possibility. As a rule these tumors are fairly rapid in growth and prone to metastasize. The patient may show some of the systemic manifestations of malignancy, whereas the patient with a hemangioma is practically always in good general health. Myoblastomas and rhabdomyomas are usually malignant, extremely rare, and as a rule occur in tissues other than voluntary muscle.

Hemangiomas of muscle have been confused with a large variety of inflammatory lesions, as already enumerated. The onset clinically, often following trauma, with the accompaniment of pain and local tenderness, accounts for the relative frequency with which such diagnoses are made. Indeed, it is entirely possible for a hemangioma to become inflamed following trauma, and histologic evidence of this was noted in several of the specimens removed at operation. In most cases, however, the absence of fever and leukocytosis militates against the diagnosis of an inflammatory lesion. Serologic tests should rule out syphilis. In cold abscess or tuberculous myositis an exploratory puncture may show thin serous fluid with caseous detritus. In nonspecific chronic myositis there is a history of repeated trauma followed by the appearance of an extremely firm, hard mass. Myositis ossificans may be diagnosed by roentgenography which demonstrates bone formation within the muscle.

In hematomas aspirated blood is not normal as in hemangiomas, but is dark if removed early and is serum if removed later. Furthermore, the mass remains smaller following aspiration, whereas a hemangioma again resumes its previous size.

Finally, in the unusual instances in which the tumor pulsates and a bruit is heard, as for example in the authors' first case, the diagnostic possibility of aneurysm must be entertained. The salient features in the differential diagnosis of hemangiomas and aneurysms are summarized in Table VII, including percentages of exceptions whenever possible.

TABULAR VIII
VARIOUS TYPES OF TREATMENT AND RESPECTIVE END-RESULTS

TREATMENT AND RESULTS

TREATMENT		RESULTS							
	No	%	IMPROVEMENT OR CURE No	%	RECURRENCE OR NOIMPROVEMENT No	%	DEATH No.	%	NO STATEMENT No
I LOCAL EXCISION	265	79.1%	240	90.6%	13	4.9%	—	—	12
II PARTIAL EXCISION	17	5.1%	11	64.7%	3 ^(a)	17.6%	—	—	3
III AMPUTATION	4	1.2%	2	50.0%	1	25.0%	—	—	1
IV INJECTION OF SCLEROSING SOLUTION	3	0.9%	3	100%	—	—	—	—	—
V X-RAY THERAPY	2	0.6%	2 ^(b)	100%	—	—	—	—	—
VIMISCELLANEOUS	44	13.1%	11	25.0%	3	6.8%	1	2.3%	29
A EX FOLLOWED BY ROENTGEN THERAPY	5	1.5%	3	60.0%	1	20.0%	—	—	1
B EX XCISION FOLLOWED BY RADIUM THERAPY	1	0.3%	—	—	1	100%	—	—	—
C EX XCISION FOLLOWED BY ELECTROCOAGULATION	1	0.3%	1	100%	—	—	—	—	—
D EX XCISION FOLLOWED BY INJECTION OF SCLEROSING SOLUTION	1	0.3%	1	100%	—	—	—	—	—
E EX HERAPY FOLLOWED BY EXCISION	1	0.3%	—	—	1	100%	—	—	—
F EX AND ACHILLES TENOTOMY	2	0.6%	2	100%	—	—	—	—	—
G EX TENOTOMY	2	0.6%	2	100%	—	—	—	—	—
H EX ZATION (GALVANIC)	1	0.3%	1	100%	—	—	—	—	—
I - ENT NOT STATED OR NONE GIVEN	30	9.0%	1	3.3%	—	—	1 ^(c)	3.3%	28
TOTAL	335		269	80.3%	20	6.0%	1	0.3%	45

(a) In case of Bierhus amputation was performed 8 months later
In case of Furkroger a Pirgoff amputation was subsequently performed
(b) In case of Fulton and Sosman there was previous exploratory incision and biopsy
(c) Death of a premature infant one half hour after delivery

TREATMENT AND RESULTS

The various types of treatment employed and the respective end-results are summarized in Table VIII

I In 265 cases (79 per cent) the tumor was locally excised, with improvement or cure in 90 per cent. The ideal in treatment is to effect complete surgical excision well beyond the confines of the tumor before excessive growth and irreparable deformity have occurred, to achieve good hemostasis, and to preserve or restore normal function of the part. General anesthesia is the one of choice in most instances. Surgical extirpation is comparatively easy only in the circumscribed type, in which the tumor may often be removed by simple enucleation. In the partially circumscribed or diffuse types, excision is attended with much greater technical difficulties, since it is desirable to resect muscle tissue well beyond the limits of the tumor and since important contiguous large vessels or nerves are apt to be injured. In at least 40 cases including the authors' first case, the problem of control of hemorrhage was a major issue of the operation, and in several cases large hematomas developed postoperatively. The employment of measures to obtain as nearly a bloodless field as possible is advocated both to prevent hemorrhage and to permit visualization of all parts of the tumor. This may be accomplished by the use of a tourniquet (authors' Case 2), Esmarch bandage (Montant, Sorensen, Case 1, Huet, Case 2), or ligation of large vessels of supply to the tumor either permanent (Owen, Luz, Case 1), or temporary (authors' Case 1). Recurrence or no improvement occurred in 13 cases (5 per cent). Further surgery may thus be required secondarily to remove remnants missed at operation or to correct deformities following necessarily wide removal.

II Partial excision was performed in 17 cases (5 per cent) with improvement resulting in 65 per cent. It was employed in cases in which complete removal was impossible without damaging large nerves or blood vessels, or in which hemorrhage became so marked that the operation had to be terminated (case of McNealy). Partial excision alone was associated with recurrence or lack of improvement in 18 per cent of the cases in which it was employed. It was sometimes followed by other types of treatment as roentgenotherapy (Thomas, Case 1), radium therapy (Davis and Kitlowski, Case 7), sclerosing solution (Pomeranz and Tunick, Case 4), and electrocoagulation (Cascio), usually with improvement. In Furlkroger's case and Case 1 of Riethus amputation was subsequently required.

III Amputation is reserved for those cases in which previous attempts at excision have failed (Furlkroger, Riethus), or in which the tumor is so extensive and deformity so marked that simple removal would not suffice (Nast-Kolb, Verebely, Mauro, Case 1, Davis and Kitlowski, Case 2).

IV Pomeranz and Tunick advocate the use of sclerosing agents, stating that such a measure avoids open operation and may afford satisfactory relief. Kidner states that small hemangiomas of muscle may be treated in this manner with success, but that in large ones it is difficult to reach all parts of the tumor and there is danger of producing necrosis. Peyton and Leven,

in a limited experience, claim satisfactory results with this method. The material is injected at intervals of from one to several weeks, depending on the amount of reaction produced, preferably into, but permissibly about, the vessels of the angioma, applying proximal pressure to lessen the tendency of the sclerosing agent to diffuse beyond the angioma.

Other authors, such as Watson and McCarthy, commenting on a series of over 1000 hemangiomas in general, including ten of skeletal muscle, do not recommend this form of treatment, stating that the fast flowing blood stream sweeps the solution out of the large sinuses before sclerosis or thrombosis can be effected, and that even when compression is maintained during and immediately after injection the results are not satisfactory.

The very few reports in the literature are not sufficient to warrant definite conclusions as to the value of the method. It seems that at best, however, this type of treatment is a palliative one, relieving symptoms or reducing the size of the tumor without effecting a definite cure. Its ultimate value may be in its judicious combination with other methods of treatment such as partial excision or roentgenotherapy in those very widespread cases in which only amputation would seem to suffice.

V According to Watson and McCarthy, high voltage roentgen ray may be used in the treatment of inoperable extensive muscle angiomas. These authors have observed that the radiosensitivity varies in inverse proportion with the age of the patient, responding best in infants under three months and less after six months of age. Clinical experience indicates, however, that these angiomas do not respond as well to irradiation as those of the skin and brain. Deep roentgenotherapy alone was used in the treatment of venous hemangiomas of muscle, followed by relief of pain and decrease in the size of the intercommunicating vessels, in Cases 1 and 4 of Fulton and Sosman. The decrease in the size of the vessels was demonstrated by the comparison of venograms, thus rendering it difficult to be certain that the decrease was due to the roentgenotherapy alone, since the radiopaque solution used to outline the angioma in itself acts as a mild sclerosing agent, and, indeed, was used by Pomeranz and Tunick as a form of treatment.

In addition to its possible value in very extensive cases in which complete removal is impossible, roentgen ray radiation may also be indicated post-operatively in those cases in which the histologic picture of the tumor is more cellular than usual (authors' Case 1), or in which there is a suspicion of malignant degeneration (case of Teller, Solis-Cohen, and Levine). In such cases local recurrence or even metastasis may possibly be prevented or delayed.

VI Miscellaneous forms of treatment accounted for 13 per cent of the cases. Some of the combinations listed in Table VIII have already been discussed. Radium therapy was employed once prior to excision (Thomas, Case 2), and once following partial excision (Davis and Kitlowski, Case 7), with an unsatisfactory outcome in both instances. Cauterization with galvanic current, followed by cure after several months of treatment, was reported by Wharton. Achilles tenotomy, aimed only at correction of the orthopedic

TABLE IX
CASES OF HEMANGIOMATOUS TUMORS OF SKELETAL MUSCLE
Supplementing the Table of Davis and Kilbourn and Extended by Jenkins and Delaney

No	Author	Age Sex	History	Findings Muscle Involved	Preoper Diag Treatment Result	Pathologic Type
1	Bartoli	24 M	Painless tumor for indefinite period	Walnut sized tumor	Excision	Cavernous hemangioma
2	Biasini	22 M	Slowly growing tumor since age 1	Tongue and sternocleidomastoid	Recovery	Angiocavernoma
3	Bishop	19 M	Recurrent following removal at age 5	Soft reducible nontender tumor	Angiocavernoma	
			Swelling of leg for two years and slight limp	Sternocleidomastoid	Excision Recovery	
4	Bocchi (Faldini)	8 F	Tumor of anterior lower third of arm following trauma two years previously	Orange sized freely movable swelling of posterior surface of leg Atrophie calf muscles Pressure erosion of fibula and calcification in soft tissues on roentgen ray Probably peroneus longus	Partial excision	Diffuse hemangioma
5	Bouquet and Beaujeu	? M	Painful area on forearm for two years	Almond sized tender mass Forearm held preferably in flexion Eburnation of cortex of humerus on roentgen ray Brachialis Forearm diffusely swollen soft, and fluctuant Multiple angiolihs on roentgen ray Muscles of forearm	Excision and deep roentgen ray therapy	Small islets of heterotopic bone in stroma
6	Cace	13 F	Right leg slightly larger than left since birth and painful on exertion	Pes equinovarus Periosteal reaction and curving of fibula on roentgen ray	Inflammatory lesion of humerus	Diffuse hemangioma
7	Cace	35 F	Enlarging tumor of posterior aspect of elbow since adolescence	Gastrocnemius Hen's egg sized soft irreducible tumor Overlying skin bluish Limitation of flexion roentgen ray neg	Excision and deep roentgen ray therapy	Infiltrating cavernous hemangioma
8	Calka	39 M	Enlarging swelling of upper part of forearm for ten years, following trauma	Ticeps brachii Fist sized swelling containing a pea sized painful lump Multiple phleboliths on roentgen ray	Excision	Diffuse angioma fibrosa
9	Carnevali	13 F	Painful knee and thigh for six years	Muscles of forearm Painful firm swelling of thigh posteriorly angioliths on roentgen ray	Excision	Circumscribed angiomatous tumor
10	Carnevali	17 M	Left lower extremity underdeveloped and painful for two years	Biceps femoris Tender, hazel nut sized tumor on medial aspect of thigh Roentgen ray neg Vastus medialis	Excision Recovery	Diffuse cavernous hemangioma

HEMANGIOMATA OF MUSCLE

TABLE IX (continued)
involved;

No.	Author	Age	Sex	Duration	Location	History	Findings	Diagnosis	Treatment	Result
12	Carnevali	7	F	Painful calf for one year	Involved leg slightly underdeveloped	Equinus	Röntgen ray neg	Pes equinus	Biopsy and amputation	Diffuse cavernous hemangioma
13	Carnevali	2	F	Painful swollen plantar surface of foot for six months	Soft, tender tumor on medial border of foot	Short plantar muscles	Tender walnut-sized tumor of calf	Gastrocnemius	Excision	Recovery
14	Doederlein	6	F	Pain in leg for two years and swelling of calf for one year	Origin in right half of diaphragm with extension to serratus ant	Intercostal muscles and hypophasia of rt lung and abdominal walls	Soft mass enlarging on obstructing return blood flow	Masseter	Excision	Recovery
15	Falcao	New born	M	Death 30 min after premature delivery	Soft compressible tumor	Extensible pulsation, Roentgen ray neg	Extensor digitoris pedis	Almond-sized	Excision	Angioma
16	Forty (Leather)	23	F	Tumor of side of face for five years	Surface of thigh	Roentgen ray neg	Extensor digitoris pedis	Almond-sized	Excision	Angioma
17	Freeman	20	F	Painful swelling of dorsum of foot for 13 mos	Soft compressible tumor	Extensible pulsation, Roentgen ray neg	Extensor digitoris pedis	Almond-sized	Excision	Angioma
18	Fulton and Sosman (Case 1)	10	F	Painful tumor of thigh for past five mos, following trauma one year	Surface of thigh	Roentgen ray neg	Extensor digitoris pedis	Almond-sized	Excision	Angioma
19	Fulton and Sosman (Case 2)	23	F	Painful tumor of thigh for past five mos, following trauma one year	Surface of thigh	Roentgen ray neg	Extensor digitoris pedis	Almond-sized	Excision	Angioma
20	Fulton and Sosman (Case 4)	32	F	Painful tumor of thigh for past five mos, following trauma one year	Surface of thigh	Roentgen ray neg	Extensor digitoris pedis	Almond-sized	Excision	Angioma
21	Gaudier	20	M	Painful foot for four years	Soft, tender mass containing a hard nodule	Soft tissue shadow with phleboliths	Triceps brachii	Tender swelling of sole	Plantar flexion of toes	Phleboliths on roentgen ray
22	Huard Joyeux and Vu Thinh	9	F	Enlarging tumor of thigh for one year	Soft, tender mass containing a hard nodule	Soft tissue shadow with phleboliths	Triceps brachii	Tender swelling of sole	Plantar flexion of toes	Phleboliths on roentgen ray
		11	M	Painful forearm for 15 years	Diffuse soft nontender tumor of ant aspect of forearm	Grasp weak	Angioliths on roentgen ray	Flexor muscles of forearm	Enlarging tumor of thigh for one year	Soft, tender mass containing a hard nodule

TABLE IV (continued)

No	Author	Age Sex	History	Findings Muscle Involved	Proper Diag Treatment Result	Pathologic Type
23	Huet	22 M	Tumor of forearm for five years with pain and paresthesias for two years Surgical exploration one year previously	Walnut sized soft nontender tumor on aspect of forearm Calcified nodules on roentgen ray Muscles of forearm	Angioma of muscle Excision Pulmonary tuberculosis six mos later	Diffuse capillary angioma
24	Huet	25 M	Painful tumor of sole excised 15 years previously but recurred	Firm tender turkey's egg sized tumor with ulceration of sole Angioliths on roentgen ray Plantar muscles	Angioma of plantar muscles Esmarch bandage and excision Complete recovery	Angioma
25	Imperati	13 M	Painful calf for four years	Oval tumor of calf Blood on aspiration Roentgen ray neg Gastrocnemius	Angioma Biopsy	Diffuse cavernous hemangioma
26	Josefsson (V Rosen)	12 F	Painful swollen calf for past six years	Tender mass in calf Pes equinus and atrophy of leg Roentgen ray neg Soleus	Excision Achillotendon only two weeks later Good correction of deformity	Diffuse cavernous hemangioma
27	Kidner	24 F	Persistent tenderness of calf following excision of tumor associated with trauma	Compressible mass of calf seven inches long Gastrocnemius and soleus	Angioma Excision followed by two subsequent excisions within six mos No recurrence in 15 years	Diffuse cavernous hemangioma
28	Kidner	10 F	Pain in leg and lump for four years Lump in calf for one year	Tender tumor of calf Congenital malformation of tarsus Gastrocnemius and soleus	Excision and roentgen-ray therapy Brunt developed probably due to A-V connection	Diffuse cavernous and telangiectatic hemangioma
29	Kidner	39 M	Painful swelling of calf for seven years	Soft tumor of calf Few varicose veins Gastrocnemius and soleus	Cavernous angioma Excision Relief of pain	Grossly a diffuse cavernous hemangioma
30	Kidner	8 M	Swelling of leg and lump for three years Severe pain on one occasion	Soft tender swelling lateral to Achilles tendon Hypertrophy of tibia on roentgen ray Gastrocnemius, soleus, peronei	Cavernous angioma Incomplete excision Relief of pain	Diffuse cavernous hemangioma
31	Kriener	58 M	Incidental discovery	Increase in circumference of forearm five cm Nodules palpable Swelling disappears on elevation Phleboliths on roentgen ray Muscles of forearm	Cavernous hemangioma Biopsy	

HEMANGIOMATA OF MUSCLE

TABLE IX (continued)

32	Luz	20 M	Enlarging mass on buttock for three years	Compressible fluctuant mass with pulsation and systolic bruit	Gluteus maximus	Gluteal aneurysm Ligation of hypogastric artery and partial excision Recovery	Diffuse hemangioma
33	Luz	47 M	Slowly growing tumor on thoracic area of back	Firm compressible nontender tumor	Trapezius	Lipoma Excision Recovery	Diffuse hemangioma
34	MacDermott	24 F	Pain and swelling of calf for seven years	Calf enlarged	Gastrocnemius and soleus	Pseudo-ectriplantiasis or angioma Excision No recurrence in two years	Diffuse hemangioma
35	MacDermott	12 M	Swelling to right of middorsal region for three years	Resilient duck's egg-sized mass	Erector spinae	Hemangioma, sarcoma, spinal caries, hernia Well after two years	Partially circumscribed angioma
36	Maier	21 M	Enlarging mass in arm following trauma four months previously	Tender hen's egg sized mass on inner posterior aspect of arm	Triceps brachii	Excision Recovery	Partially circumscribed fibrohemangioma
37	Mauro	8 F	Pain and paresthesia of forearm and hand for two years	Palmar and forearm swelling increasing with obstruction of venous return	Volar muscles of forearm	Excision Recovery	Diffuse capillary and arterial angioma
38	Mauro	40 F	Painful swelling of interscapular area for one year	Lemon sized soft tumor	Rhomboides	Amputation of lower third of arm	Diffuse cavernous hemangioma
39	McNealy	28 M	Tumor of popliteal space for several years Attempted excision nine months previously	Tumor mass of popliteal space	Semimembranosus	Excision and further excision two mos later	Encapsulated cavernous sarcoma with degeneration
40	Mondolfo	12 M	Painful calf and pes equinus for two years	Hard tender pigeon's egg-sized tumor of calf	Gastrocnemius	Excision Probable cure	Hemangioma
41	Mondolfo	9 F	Increasing swelling of calf since birth Pain in leg for past five years	Leg underdeveloped	Gastrocnemius	Excision and application of apparatus to correct pes equinus	Circumscribed angioma musculare
42	Mondolfo	21 F	Enlarging of lower extremity, contracture of knee and pes equinus since age of 14	Enlargement and soft consistency of calf	Muscles of calf	Fair correction Angioma	Diffuse angioma musculare
				Several small hard nodules	Slight pes equinus	Two excisions six mos apart Partial correction of pes equinus	
				Irregular soft tissue shadows on roentgen ray	Muscles firm and elastic	Diffuse angioma primary in muscles	
				Muscles of knee and pes equinus Irregular soft tissue shadows on roentgen ray	Flexion contracture	Amputation refused	

TABLE IV (continued)

No	Author	Age Sex	History	Findings Muscle Involved	Treatment Result	Pathologic Type
43	Mondolfo	10 F	Painful swollen calf with increasing pes equinus since birth	Soft, tender swelling of calf and marked pes equinus Irregular soft tissue shadow on roentgen ray Muscles of calf Decrease in size on elevation Pain on moving fingers Perosteal reaction on roentgen ray Arteriography neg Volar muscles of forearm Soft tender egg sized tumor, increasing in size when patient stands Biceps femoris Elastic ill defined egg sized tumor decreasing on elevation of arm Limitation of pronation Volar muscles of forearm Tumor above lateral aspect of knee on lateral aspect of thigh and on buttock Flexion of knee limited Blood on aspiration of knee and buttock tumors Phleboliths on roentgen ray Biceps femoris, vastus lateralis, gluteus maximus Lemon sized compressible expansile pulsating tumor Roentgen ray neg Muscles of jaw	Angioma of muscles Achillotomomy Partial correction six months later Syphilitic tenosynovitis Esmarch bandage and excision Relief of pain, normal function Hemangioma of muscle Excision Recovery Hemangioma of muscles Excision Recovery Multiple primary muscle angomas Excision Recovery	Diffuse cavernous hemangioma Partially circumscribed cavernous hemangioma Diffuse cavernous hemangioma Diffuse cavernous hemangioma
44	Montant	23 M	Trauma to forearm four years previously followed by gradually increasing pain and swelling	Pes equinovarus Atrophy of foot and calf Ulcer on plantar surface and edema of dorsum Nodular soft tissue mass and phleboliths on roentgen ray Venogram showed dilated vessels Muscles of foot	Well 33 months later Angioma Injection of sclerosing agents Ulcer healed in six weeks Contour of foot still normal three years later	
45	Nicolosi	7 F	Enlarging painful swelling posteriorly on thigh for three years	That tender fluctuating masses on dorsum of forearm Veins of palm dilated Phleboliths on roentgen ray Venogram outlined clumps of vessels Muscles of forearm	Injection of sclerosing agents Tumor obliterated and pain gone three weeks later	
46	Nicolosi	9 M	Enlarging painless tumor of forearm for one year			
47	Oi and Yazaki	16 M	Painful swelling of knee and buttock since childhood			
48	Owen	24 F	Enlarging painful tumor of side of face since age of seven Attempted operation and roentgen ray therapy at age of 19		Ligation of external maxillary vessels Excision	Diffuse cavernous hemangioma
49	Pomeranz and Tunick	5 M	Tumor of sole since birth Ulceration and pain following roentgen ray and radium therapy			
50	Pomeranz and Tunick	3 M	Painful swellings of forearm and hand since birth			

No.	Author	Age	Sex	History	Examination	Diagnosis	Treatment	Result
51	Pomeranz and Tunick	3	F	Slowly growing painful tumor of leg since birth	Hard, irregular swelling on ant surface of leg roentgen ray	Two tender masses behind external malleolus	Excision	Diffuse angiomatosis (biopsy report)
52	Pomeranz and Tunick	17	M	Injured elbow 14 years previously Four months later developed an enlarging soft tissue swelling	Muscles of leg Lobulated, semi elastic mass on elbow Pres-roentgen ray Muscles of forearm	Phleboliths on	Excision	Phleboliths on
53	Poos	43	M	Increasing exophthalmos of right eye for five years	Exophthalmos and limitation of motion Roentgen ray neg Muscles of cone of orbit	Exophthalmos increases on bending Limita-tion of motion Clouding of orbit on roentgen ray	Excision	Mass reduced pain gone and vessels obliterated one year later Retrobulbar cyst Kronlein operation and excision
54	Poos	12	F	Increasing exophthalmos of left eye for two years	Muscles of cone of orbit Lemon sized clastic tumor with pulsation and continuous fremitus and murmur accentuated in systole	Biceps brachii Tender swelling of calf Gastrocnemius and soleus Soft, tender almond-sized tumor Radial muscles of forearm	Excision	Circumscribed hem-angioma cavernosum
55	Picardi (Chrissneri)	35	F	Increasing swelling of arm for ten following unsuccessful surgical in-tervention	Swelling of calf since age 1, and Enlarging painful tumor following fall on elbow	Enlarging tumor of forearm since youth	Excision	Circumscribed cavern-ous hemangioma
56	Ricci	8	F	Swelling of calf since age 4	Painful swelling of calf since age 1, and Enlarging painful tumor following fall on elbow	Enlarging tumor of forearm since youth	Excision	Diffuse angiomatosis
57	Rocher and Roudil	9	M	Enlarging painful tumor following fall on elbow	Enlarging tumor of forearm since youth	Painful swelling of lateral chest wall for one year	Excision	Diffuse cavernous hemangioma
58	Rocher and Uzac	46	F	Enlarging tumor of forearm since youth	Painful swelling of lateral chest wall for one year	Painful thigh, following trauma five years previously	Excision	Circumscribed angiofibroma
59	Serra Lavencia, and Frega (Sussini)	24	F	Painful swelling of lateral chest wall for one year	Painful thigh, following trauma five years previously	Painful swelling of arm following trauma two months previously Similar swelling excised 23 years previously	Excision	Diffuse capillary hem-angioma containing a small osteoma Arteriovenous angiomatosis
60	Settergren	21	M	Painful thigh, following trauma five years previously	Painful swelling of arm following trauma two months previously Similar swelling excised 23 years previously	Painful swelling of arm following trauma two months previously Similar swelling excised 23 years previously	Excision	Diffuse cavernous hemangioma
61	Settergren	27	M	Painful swelling of arm following trauma two months previously Similar swelling excised 23 years previously	Painful swelling of arm following trauma two months previously Similar swelling excised 23 years previously	Painful swelling of arm following trauma two months previously Similar swelling excised 23 years previously	Excision	Diffuse cavernous hemangioma

TABLE IV (continued)

No	Author	Age Sex	History	Findings Muscle Involved	Roentgen-ray Treatment Result	Pathologic Type
62	Settergren	57 F	Chest trauma 29 years previously followed by a lump and aching pain	Firm slightly movable walnut sized tumor	Excision	Cavernous hemangioma
63	Soli	7 M	Tumor of neck discovered by a barber two years previously	Musculature at tip of twelfth rib Firm reducible nontender walnut sized tumor	Hemangioma of muscle Excision	Circumscribed cavernous hemangioma
64	Sorensen	47 F	Painful swelling of dorsum of hand for one year	Splenius capitis Soft noncompressible tumor on fourth metacarpal interspace Atrophy and deformity of fourth and fifth metacarpals on roentgen ray	Recovery	Hemangiofibroma cavernosum
65	Sorensen	25 F	Painful nodule in first metacarpal space for one year	Interosseus Tender freely movable pea sized nodule Phleboliths on roentgen ray	Hemangioma of muscle Excision	Circumscribed hemangioma
66	Sorensen	15 F	Nodule of second metacarpal interspace for two years painful for six months	Adductor pollicis Tender, walnut sized mass Roentgen ray neg	Well three years later Hemangioma of muscle Excision	Circumscribed hemangioma
67	Stewart	8 M	Nodule of thigh for one year	Interosseus Hard nodule on external surface	Well one year later Sarcoma Excision	Circumscribed hemangioma
68	Talbot and du Bourgnet	? M	Pain in lower thigh on exertion	Vastus lateralis Tender fluctuant egg sized mass Size varies with position of limb Blood on aspiration	Roentgen ray neg Vastus internus Large tumor mass of ant aspect of leg Periosteal proliferation of tibia and fibula on roentgen ray	Angiolipoma
69	Teller Sol's Cohen, and Levine	63 F	Tumor of leg for 22 years enlarging during the past ten years Pain on walking	Tibialis anterior Painless, compressible chest tumor Purplish discoloration of overlying skin Blood on aspiration	Recovery Periosteal fibroma or fibrosarcoma Excision followed by roentgen ray therapy	Diffuse cavernous hemangioma
70	Thomas (Hedblom)	6 M	Tumor of chest since birth Lymphangioma of inguinal region since birth and congenital malformation of feet	Muscles of chest wall	Partial excision and roentgen ray therapy Well two years later Died four years after inguinal operation	Hemangioma with secondary inflammatory changes
71	Thomas	3 M	Swelling, blueness, and pain in knee for two years	Fluctuant swelling size of half a lemon Roentgen ray neg Quadriceps femoris	Radium therapy and excision Second operation one year later for recurrence Improved five months later	Cavernous hemangioma
72	Thomas and Hark	15 F	Painful enlarging mass in calf for eight years following trauma	Tender mass 10 x 20 cm adherent to Achilles tendon Gastrocnemius	Excision and later excision of tumor involving flexor hallucis longus Primary healing	Diffuse cavernous hemangioma

HEMANGIOMATA OF MUSCLE

TABLE IX (continued)

73	Thomas and Hark	7	Painful knee and limp for nine months	Flexion contracture of knee exquisitely tender	Popliteal space Calcareous shadows on Semimembranosus	Angioma? Malignancy? Excision of two masses and one involving posterior tibial nerve not removed	Cavernous hemangioma
74	Truesdell	30	Backache for five years	Slight prominence below twelfth rib posteriorly	Erector spinae	Excision and exploratory operation	Hemangioma
75	Verébely	20	Enlarging painful swelling of calf for three years	Red birthmark of thigh removed eight years previously	Leg three times enlarged	Relief of symptoms	Hemangioma
76	Watson and McCarthy	14	Painful swelling of forearm for five years	Trauma five years previously, followed by a nodule which enlarged and became tender	Pes equinus and edema of foot	Sarcomatous tumor of muscle	Extensive hemangiomatosis of muscle
77	Weaver (Francisco)	10	Pain and weakness of leg and tenderness of thigh following diphtheria eight years previously	Pain in knee for seven years	Knee held at 45°	Supracondylar amputation	Cavernous hemangioma
78	Weaver	20	Swelling and pain in calf for four years	Enlarging mass of thigh, following delivery five years previously	Flexor and peroneus muscles of leg	Recovery	Cavernous hemangioma
79	Weaver (Francisco)	13	Pain in knee for seven years	Enlarging mass of thigh, following delivery five years previously	Swelling 7 x 4 x 2 cm	Excision	Cavernous hemangioma
80	Zappala	11	Swelling and pain in calf for four years	Enlarging mass of thigh, following delivery five years previously	Muscles of forearm	Excision	Cavernous hemangioma
81	Authors (Shallow)	35	Enlarging mass of thigh, following delivery five years previously	Pain on exertion	Small, tender, compressible tumor of foot	Excision	Cavernous hemangioma
82	Authors (Shallow)	10	Enlarging painful lump following trauma six months previously		Extensor digitorum brevis	Excision	Cavernous hemangioma
					Small, tender, nodule above lateral condyle of knee	Excision	Cavernous hemangioma
					Atrophy of thigh and calf	Excision	Cavernous hemangioma
					Vastus lateralis	Excision	Cavernous hemangioma
					Atrophy of thigh and calf	Excision	Cavernous hemangioma
					limited to 160° and flexion to 85°	Excision	Cavernous hemangioma
					on roentgen ray	Excision	Cavernous hemangioma
					Vastus lateralis	Excision	Cavernous hemangioma
					Tender, somewhat reducible, egg-sized tumor	Excision	Cavernous hemangioma
					Soft tissue shadow on roentgen ray	Excision	Cavernous hemangioma
					Gastrocnemius	Excision	Cavernous hemangioma
					Slightly movable mass on thigh	Excision	Cavernous hemangioma
					bruit Roentgen ray neg	Excision	Cavernous hemangioma
					Vastus lateralis, gluteus maximus, tensor fasciae latae	Excision	Cavernous hemangioma
					Soft tender walnut-sized mass	Excision	Cavernous hemangioma
					Roentgen ray neg	Excision	Cavernous hemangioma
					Triceps brachii	Excision	Cavernous hemangioma
					Systolic bruit	Excision	Cavernous hemangioma
					Angioma or aneurysm	Excision	Cavernous hemangioma
					Temporary ligation of common iliac artery	Excision	Cavernous hemangioma
					Excision and roentgen ray therapy	Excision	Cavernous hemangioma
					function preserved	Excision	Cavernous hemangioma
					Hemangioma or aneurysm	Excision	Cavernous hemangioma
					Excision followed by recurrence two years later	Excision	Cavernous hemangioma
					further excision	Excision	Cavernous hemangioma
					Normal function restored	Excision	Cavernous hemangioma
					Excision followed by recurrence two years later	Excision	Cavernous hemangioma
					further excision	Excision	Cavernous hemangioma
					Normal function restored	Excision	Cavernous hemangioma

Note Since completion of this article two cases of hemangio endothelioma of skeletal muscle have been reported by Stout and one case of venous hemangioma by Light

Pathologic
re-

is permitted in two cases, followed by improvement. In 30 cases (80 per cent) the treatment was not stated or else no definitive treatment was given. In six of these only a biopsy was performed, and in two the tumor was exposed without being excised. In one case amputation was performed, and there is no report of the outcome. In consideration of the various forms of treatment, it is evident that surgical excision offers the only hope of permanent cure. In late and widespread cases such a procedure is often unfeasible, and a judicious combination of partial excision followed by deep roentgenotherapy or use of sclerosing agents may be employed.

PROGNOSIS

Complete recovery is the rule, and in spite of the frequent sacrifice of large amounts of muscle tissue the functional result is usually very satisfactory. In both of the authors' cases there was extensive removal of muscle, and yet in Case 1 normal function was preserved and in Case 2 restored. There was no surgical mortality for the entire series.*

Recurrence locally of the tumor or lack of improvement was reported in 6 per cent of the series, and postoperative deformity in 4 per cent. There was limitation of motion in three cases, a limp in one, persistence of limp in one, loss of function of a muscle in one, atrophy of muscle in one, persistence or occurrence of contracture in four, pes equinus deformity in one, and other deformities in two.

Although in several cases an increased cellularity of the tumor, histologically, was suggestive of malignancy, there are no recorded cases primary in muscle in which metastasis has occurred.*

The only death occurred in Doederlein's case of a premature infant one-half hour after delivery.*

SUMMARY AND CONCLUSIONS

An analytic review is made of 335 cases of primary hemangiomatous tumors of skeletal muscle. Included are two cases of our own, one most unusual and the other ordinary for comparison.

The disease occurs about equally in both sexes and most frequently (85 per cent) during the first three decades of life.

The prevailing view is that hemangiomas are congenital tumors, originating from abnormal embryonic sequestrations of vascular tissue. Trauma and systemic infection acting as secondary factors may in some instances modify subsequent growth and clinical manifestations.

The lesion arises in the vascular plexus of the muscle or in the perimysium between the muscle fibers, and grossly often resembles a muscle containing varicose veins. Diffuse, partially circumscribed, and circumscribed types are recognized. The diffuse type is by far the most frequent. Microscopically, the tumor consists of vascular elements in a connective tissue stroma, and is

* Since this article was written Stout has reported a case of hemangio-endothelioma of the erector spinae muscles followed by evidences of lung metastases and symptoms of paraplegia four months after operation, and death after seven months. No autopsy findings were mentioned.

classified as cavernous, capillary, venous, or arterial. Although pur seldom exist, the cavernous variety is the most common. Growth multicentric proliferation of endothelial cells forming vascular chan practically no tendency to anastomose with the normal vessels in th tissue. There are no proven cases of metastasis from a primary hemangioma, although malignant degeneration has been reported as p in a few instances.

The diagnosis was correctly made in only 19 per cent of the c difficulty being due mainly to the comparative rarity of the lesion and depth of the tumor. The history usually reveals a clinical onset early in life often following trauma to the part, and pain of varying degree. On physical examination, a mass, usually soft and often tender, sometimes changing in size and consistency with change of posture, is noted within the muscle. The thigh is most commonly involved, especially the quadriceps femoris muscle. Deformity and functional impairment are present in about one fourth of the cases. The diagnosis may be confirmed by aspiration of blood from the tumor and by the presence of phleboliths on roentgenologic examination. Angiography may also be employed as an adjunct in diagnosis or to evaluate the results of treatment.

In the differential diagnosis one must consider benign and malignant tumors, inflammatory lesions, and in some instances aneurysms.

The procedure of choice in treatment is early complete surgical excision well beyond the confines of the tumor, with good hemostasis, and with preservation or restoration of normal function of the part. This was the treatment employed in 79 per cent of the cases, with improvement or cure in 90 per cent. In cases in which malignant degeneration is suspected, postoperative deep roentgenotherapy is advocated.

There was no surgical mortality for the entire series. Local recurrence or lack of improvement was reported in 6 per cent of the cases and postoperative deformity in 4 per cent.

Early diagnosis and wide surgical excision should aid in reducing postoperative recurrence, functional impairment, deformity, and the remote possibility of malignant degeneration.

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ACUTE RETROPERITONEAL ABSCESS AND PHLEGMON*

A STUDY OF SIXTY-FIVE CASES

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ACUTE RETROPERITONEAL INFECTIONS derived from a variety of sources have long been known to be grave lesions which at times present great difficulties both in diagnosis and in treatment. The earliest consideration of the subject was that of Abille,¹ in 1854, who reported eight cases of suppuration in the retroperitoneal tissues. Since that early contribution, the literature is composed essentially of reports dealing with individual cases. Our purpose is to present a comprehensive consideration of infections of the retroperitoneal tissues with special reference to clinical classification, pathogenesis, clinical manifestations, diagnosis, and operative treatment. This paper is based on a study of 65 cases encountered on the Surgical Services of the Mount Sinai Hospital, New York, in the 18-year period from 1925 to 1942. We shall present 15 cases in summary† as the best means of illustrating the many problems involved.

CLASSIFICATION

An analysis of the 65 cases of acute retroperitoneal infections led to a simple classification on the basis of combined anatomic, pathologic, and clinical considerations. There was overlapping in some instances, but, in the main, the cases could be grouped. The classification is of clinical usefulness, and of special value in the decision as to the type of operative approach in the individual case. Infections limited to the extraperitoneal subphrenic space and to the extraperitoneal tissues of the pelvis are omitted from consideration, the former are more directly related to the problem of subphrenic abscess, and the latter are related to the rectum, bladder, prostate, and female pelvic organs. The classification of acute retroperitoneal infections is as follows:

A Localized Form Abscess

- 1 Lumbar
- 2 Iliac
- 3 Subphrenic only (omitted from consideration)
- 4 Pelvic only (omitted from consideration)

B Diffuse Form Phlegmon

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† The details of these cases will be published elsewhere at a later date.

LUMBAR RETROPERITONEAL ABSCESS

Anatomy—The lumbar portion of the retroperitoneum (retroperitoneal space) extends from the twelfth dorsal vertebra and twelfth rib to the promontory of the sacrum and the iliac crest. The floor of the space is formed by the quadratus lumborum and psoas muscles.

The fascia covering the quadratus lumborum muscle is the anterior layer of the lumbodorsal fascia. This layer is not as strong as the middle and posterior layers. The fascia covering the psoas muscle has the following attachments: above, mesially, the body of the second lumbar vertebra, laterally, the first lumbar transverse process, thus forming a funnel-shaped opening communicating with the posterior mediastinum, mesial, the bodies of the lumbar vertebrae, lateral, the anterior layer of the lumbodorsal fascia, below, the iliac fascia. It is these fascial layers which tend to confine retroperitoneal abscesses to that space and thus render difficult their early recognition and surgical management.

The kidney lies on the fascia covering the quadratus lumborum and psoas muscles. The extraperitoneal areolar tissue is somewhat condensed to enclose the kidney, adrenal gland, and renal fat in a loose envelope called the renal fascia. At the outer border of the kidney the renal fascia divides into a prerenal and a retrorenal layer to envelop the kidney. The posterior layer, also called the fascia of Gerota, fuses with the fascia on the psoas and quadratus lumborum muscles. The anterior layer is much thinner and passing medially is lost in fat in front of the aorta. The two layers of the renal fascia fuse at the upper pole of each kidney, but separate again to enclose the corresponding adrenal gland. Above this they again unite and become continuous with the aponeurotic covering of the diaphragm. The layers fail to unite below and are lost in the fat near the iliac crest. The fat inside the renal fascia separates the renal fascia from the proper capsule of the kidney and is called the perinephric fat, the fat outside the retrorenal fascia is called the paranephric fat. Under exceptional circumstances suppuration derived from the kidney can extend into the retroperitoneal space instead of producing the customary perinephric abscess.

The fascial layers over the quadratus lumborum and psoas muscles are covered by areolar and fatty tissue which forms a bed for the kidney, ascending colon, and duodenum on the right, and the kidney and descending colon on the left. Numerous lymphatic vessels traverse the retroperitoneal areolar tissue with the well known grouping of lymph nodes about the great vessels.

Pathogenesis—There were 25 cases of localized lumbar retroperitoneal infections. The sources of infection were as follows: Unknown (nine cases), distant focus (five cases), kidney (five cases), appendix (three cases), colon (two cases), and spine (one case). Although the source of infection was not determined in approximately one-third of the cases, the pathway of infection in such cases is probably *via* lymphatics in view of the rich lymphatic network traversing this region. On the other hand, it is not correct to describe

such cases as suppurative lymphadenitis unless suppurative lymph nodes are present. Thus, the lumbar retroperitoneal space was infected by direct extension from suppuration in an adjacent organ (kidney, appendix, colon, spine), by lymphatics, and by metastasis from distant foci of infection.

Trauma preceded the onset of symptoms in two cases of unknown etiology, and appeared to play a definite rôle in causation. The types of kidney lesions were multiple abscesses (two cases), calculous pyelonephritis (two cases), and carbuncle (one case). The primary suppurative foci in the metastatic cases were furuncles of the skin (two cases), acute pharyngitis (one case), chronic osteomyelitis of the femur (one case), and upper respiratory infection (one case).

Pathology—In five of the cases of unknown etiology the abscesses lay under the lumbar aponeurosis of the transversalis muscle. The abscesses were immediately retroperitoneal, pushing the peritoneum forward, in three cases. In the remaining cases, the abscess was located within the psoas muscle.

In the cases of retroperitoneal suppuration derived from the kidney, the infection had spread beyond the confines of the perinephric fat and renal fascia into the retroperitoneal tissues. Infections within the renal fascia are perinephric and not retroperitoneal. From a consideration of the anatomy, it would seem that spread of infection beyond the renal fascia should occur most readily through the thinner prerenal layer, and inferiorly where the margins of the fascia do not unite. In our cases the spread of infection was anteriorly in two, inferiorly in one, posteriorly in one, and superiorly in one. In the latter case the upward spread continued above the diaphragm and involved the lung.

The metastatic abscesses varied in position. Three under the lumbar aponeurosis, one anterior to the kidney, and one in the psoas muscle. Two of the appendiceal abscesses presented under the lumbar aponeurosis, and the other pushed the peritoneum and ascending colon anteriorly, a retroperitoneal gangrenous appendix was found in the abscess in the latter case. In one of the cases of colonic origin the abscess was anterior to the kidney, a fishbone was found in the abscess. In the other case the abscess was secondary to a carcinoma of the colon and lay under the lumbar aponeurosis. The abscess derived from the spine was secondary to an osteomyelitis of the lumbar vertebrae and was similarly situated.

Bacteriology—In the cases of unknown etiology the organisms cultured from the abscesses were *Staphylococcus aureus* in four, *Streptococcus hemolyticus* in one, *Staphylococcus albus* in one, and a mixture of *B. coli* and *Streptococcus viridans* in one. The organisms in the cases of renal origin were *Staphylococcus aureus* in two, *B. coli* in one, a mixture of *B. coli* and enterococcus in one, a combination of anaerobic staphylococcus and diphtheroids in one. The cultures of the metastatic abscesses secondary to furuncles of the skin and osteomyelitis of the femur were *Staphylococcus aureus*, in the cases secondary to acute pharyngitis and upper respiratory infection the organism was *Streptococcus hemolyticus*. *Bacillus coli* and a

mixture of *B. coli* and enterococcus were the organisms found in the appendiceal abscesses. The organism cultured from the abscesses of colonic origin was *coli*. In the case of spinal origin the organism was *Staphylococcus aureus*. Thus, the organisms varied with the source of infection, the *Staphylococcus aureus* and *B. coli* organisms predominating. It is perhaps significant that cultures from the abscesses of unknown origin grew chiefly staphylococci or streptococci, suggesting that they too may be metastatic.

Clinical Manifestations—The ages of the patients ranged from ten months to 75 years, two cases occurred in children. The history of pain and fever was common to all patients. The pain was in the lumbar region in most cases, but in some instances it was elsewhere, such other locations being the hip, thigh, abdomen and chest. Other symptoms occasionally noted were chills, vomiting and loss of weight. Cough and foul sputum were noted in the patient with pulmonary suppuration. The duration of symptoms before admission to the hospital varied from four days to nine weeks, the average period being three to four weeks. In two cases there were preceding traumas, in one case immediately before the onset of symptoms, and in the other separated by a long free interval.

On examination, there was tenderness in and spasm of the lumbar muscles on the affected side in 23 cases. This was associated with a tender mass in 16 cases, palpable in the lumbar region in nine patients and in the abdomen in seven cases. In two patients there were tender abdominal masses not associated with lumbar tenderness. There was marked abdominal distention in two cases of renal origin. The abdominal masses were usually large and located in the hypochondrium. Psoas (hip) spasm was noted in five patients.

Fever was a constant finding during the period of observation, usually between 102° and 103° F, and associated with an increase in pulse rate. A constant laboratory finding was leukocytosis, averaging 21,600 white blood cells. There was usually an associated polymorphonucleosis, averaging 80 per cent. One or more negative blood cultures were reported during the period of observation in ten patients in whom they were taken. In one case, in which the infection was secondary to multiple abscesses of the kidney, the blood culture was positive for *Staphylococcus aureus*.

Diagnosis—Although the combination of lumbar pain, tenderness in and spasm of the lumbar muscles, a mass (lumbar or abdominal), fever, and leukocytosis is diagnostic of lumbar retroperitoneal abscess, all these criteria may not be present in the earlier phases. The absence of a mass may lead to protracted observation, and we stress the value of an examination under anesthesia in cases in which muscle spasticity exists and apparently interferes with the palpation of a mass.

The nature of the lesion was often not suspected on admission to the hospital. This is borne out by the fact that the periods of preoperative observation varied from one day to one month, the average period being ten days. Occasionally a suppurative lesion was not considered, the diagnosis of neo-

plasm of the kidney being made in one patient, and intra-abdominal malignancy in another. The presence of a large mass in the hypochondrium was misleading in both cases.

In the cases of renal origin cystoscopic and pyelographic findings were negative when the source of infection was a cortical abscess or caliculi. Occasionally, as in two of our cases, roentgenograms of the spine may show a scoliosis of the lumbar spine with convexity away from the diseased side and an obscured psoas margin, a finding noted by Beer² in the roentgenologic examination of perinephric abscess. A common error is to suspect a perinephric abscess when the abscess has no such relationship to the kidney.

Treatment and Results—Operation was performed in all cases, in 21 cases the abscesses were drained through lumbar incisions, and in four cases through the transperitoneal route. Extraperitoneal drainage is, of course, advised, and in the cases in which the peritoneal cavity was traversed the diagnosis of a retroperitoneal abscess had not been made before operation. One of the two deaths in this group was due to peritonitis following transperitoneal drainage. It is for this reason that emphasis should be placed upon a final examination under anesthesia just before operation for an abscess or an inflammatory mass whose relationship to the retroperitoneal space is doubtful. If the peritoneal cavity is traversed accidentally, it would be advisable to close the peritoneum and then proceed with lumbar drainage. However, with a careful operative technique and the addition of sulfonamides, peritonitis may be avoided. In doubtful cases the lumbar incision is preferable and can be used with advantage for drainage of intraperitoneal abscesses in contiguity with the posterior parietal peritoneum.

The operative incision to be employed for a lumbar retroperitoneal abscess is one which can be termed the anterior half, or more, of the customary incision for exposure of the kidney. Special care should be taken to avoid injury to the twelfth thoracic nerve. The situation of the incision must be placed in relationship to the mass. No difficulty in entering the abscess is encountered where the abscess lies just under the lumbar aponeurosis, but where the abscess is situated more mesially in proximity to the posterior peritoneum the incision must be deepened to the peritoneum. The latter, under clear visualization, is stripped away and retracted toward the midline as the exposure is deepened in order to approach the mass.

Adequate drainage, particularly in multilocular abscesses, is necessary. By this we mean unroofing the abscess, evacuating its contents, inserting retractors, and fully visualizing all its recesses. This is followed by drainage by gauze placed as a packing, or packings, to the limits of the infection. The type of operation which terminates with the introduction of a drainage tube as soon as pus is encountered is apt to be followed by untoward complications and sequelae. Tube drainage should be reserved for those exceptional instances in which adequate unroofing of the abscess would damage important structures. In this group drainage of the abscesses resulted in fairly prompt subsidence of the clinical manifestations. On

an average, the patients were discharged from the hospital one month after operation

Five patients were readmitted to the hospital for the treatment of conditions related to the retroperitoneal abscesses. Further operative procedures were appendectomy (two cases), nephrectomy (one case), and repair of incisional hernia (one case). In one patient there was recurrence of abdominal pain, fever and persistence of the mass, further operation was not necessary.

In this group of 25 cases there were two deaths, a mortality of 8 per cent. One death occurred in a ten-month-old child with a small abscess between the kidney and the descending colon. Death was attributable to peritonitis secondary to transperitoneal drainage. The second fatality was in a 50-year-old woman with a large retroperitoneal abscess secondary to abscesses of the kidney, the patient died 36 hours after operation.

Twelve patients were followed for more than one year after operation, and were well.

COMMENTS ON FIVE ILLUSTRATIVE CASES REPRESENTATIVE OF GROUP A-1*

GROUP A-1—LUMBAR RETROPERITONEAL ABSCESS

Case 1—Trauma *Slow evolution of lumbar abscess Drainage Recovery*

COMMENT The slow evolution of a lumbar retroperitoneal abscess over a period of six weeks following a fall on the hip is noteworthy. The patient was in the hospital under observation for 18 days before operation.

Case 2—Furunculosis *Psoas abscess Drainage Recovery*

COMMENT The clinical manifestations were those of a perinephric abscess following furunculosis, but at operation there was no evidence of infection in or around the kidney. The abscess lay within the substance of the psoas muscle.

Case 3—Caulicle of kidney *Retroperitoneal abscess Drainage Recovery*

COMMENT The signs of peritoneal irritation were related to the close approximation of the abscess to the peritoneum. A review was made of 100 cases of perinephric abscess, and this was the only one in which the abscess was between the kidney and the posterior peritoneum.

Case 4—Retroperitoneal appendiceal abscess *Transperitoneal drainage Recovery*

COMMENT Operation was transperitoneal in this case because the diagnosis was appendiceal abscess. Although a large, foul, retroperitoneal abscess was drained through this approach, there was no infection of the peritoneum after operation. Drainage of a retroperitoneal abscess through the peritoneum is not advised (death in another case was due to peritonitis after such an

* The details of these cases will be published elsewhere at a later date.

approach) but with a careful operative technic and the addition of sulfonamides infection of the peritoneum is not anticipated

Case 5—*Foreign body (fishbone) abscess Preoperative Diagnosis*, *abscess of kidney*

COMMENT The preoperative diagnosis was neoplasm of the kidney, the onset of fever and tenderness being associated with supposed presence of the tumor. The colon was not visualized at operation but the fishbone had migrated through a small perforation in the bowel.

ILIAC RETROPERITONEAL ABSCESS

The first description of iliac retroperitoneal abscess was that of Pegibian¹² in 1903, who reported operations in two children for acute iliac adenitis. Since that contribution, 145 cases of iliac abscess have been reported in the literature (Largos García,⁷ Hyman,¹ Frank,³ Irwin,⁵ McCorkle and Stevenson,⁸ Ladd and Gross⁶). These reports (with the exception of the case of McCorkle and Stevenson which was an appendiceal abscess) were of cases of acute iliac adenitis. As will be brought out later, our criteria for classification of cases in this group are more strict and are confined to cases in which infections draining into such lymph nodes were demonstrable and acutely inflamed lymph nodes were present. In many reports the diagnosis is assumed and is not proved by operative findings, whereas in our cases abscesses were drained. Not all cases of acute iliac lymphadenitis go on to suppuration and abscess formation and abscesses alone are considered by us in this classification.

A review of the literature reveals that the majority of cases of acute iliac lymphadenitis occurs in childhood. There has been a variable percentage of recoveries without operation. In the group of Ladd and Gross there were 35 cases in childhood, 17 of which subsided under conservative therapy. The average operative mortality of all cases in the literature was 5 per cent.

Anatomy—In the iliac fossa the psoas and iliacus muscles are separated from the retroperitoneal tissues by the thick iliac fascia. Laterally, this fascia is fixed to the iliac crest, medially, it is attached to the brim of the true pelvis at the ileopectineal line. The iliac and transversalis fasciae become continuous with each other at the part of the inguinal ligament which is lateral to the external iliac vessels, and are firmly attached to the ligament. In the region of the external iliac vessels they pass downwards beneath the inguinal ligament, the transversalis fascia in front of, and the iliac fascia behind, the vessels. Thus, the pathway of infection from the iliac fossa to the upper thigh becomes evident. In the thigh the fasciae form a sheath for the femoral artery and vein.

In the retroperitoneal tissues of the iliac fossa are the ureter, the spermatic or ovarian vessels, and the genitofemoral nerve. The external iliac artery is separated from the psoas muscle behind and laterally by the iliac fascia. The external iliac lymph nodes form three chains around the external iliac vessels. The external iliac nodes receive lymphatics from the inguinal nodes,

the glans penis, the patients were discharged. The lower part of the abdominal wall, the vagina, the uterine bladder, the membranous portion of the urethra, and the peritoneum were readmitted to the hospital. The genitofemoral nerve passes obliquely through the retroperitoneal abscesses on the surface of the muscle.

Pathogenesis—There were 23 cases of localized iliac retroperitoneal infections. The sources of infection were as follows: Unknown (eight cases), acute iliac lymphadenitis (five cases), appendix (three cases), metastatic (two cases), sigmoid colon (two cases), uterus (two cases), and ureter (one case). The cases of acute iliac lymphadenitis were those in which infections draining into such lymph nodes were present and acutely inflamed lymph nodes were demonstrable. Considering the extensive lymphatic drainage into the external iliac lymph nodes, the likelihood of a small primary focus of infection being overlooked, and the difficulty of identifying lymph nodes in an abscess because of necrosis, it would probably be correct to include some of the cases of unknown etiology in the group of iliac adenitis. Thus the iliac retroperitoneal space was infected by direct extension from suppuration in an adjacent organ (appendix, sigmoid colon, uterus, ureter), by lymphatics, and by metastasis from distant foci of infection.

Trauma preceded the onset of symptoms and appeared to play a definite rôle in causation in four cases of unknown etiology, and in one case of acute iliac lymphadenitis. In two of these cases infected hematomas were present. Infections of the foot and thigh were the primary sources of infection in four cases. The metastatic infections originated in mastoid suppuration. The sigmoid lesions were in one case diverticulitis and in the other a perforation of unknown etiology. The appendiceal lesions were retroperitoneal appendiceal abscesses. The cases of uterine origin occurred postpartum, and after vaginal operation for uterine prolapse. Multiple operations for ureteral calculi, years before, preceded the infection of ureteral origin.

Pathology—In the cases of unknown etiology the abscesses were well localized, five were located within, or in close contact with, the psoas muscle. In the four cases of acute iliac lymphadenitis secondary to infections of the lower extremity, the lower limit of infection was at the inguinal ligament, acutely inflamed lymph nodes were found within, or in close proximity to, the abscesses.

The appendiceal abscesses were well localized in the retroperitoneal iliac region but in no case was the appendix visualized at operation. The abscess secondary to perforation of the sigmoid was of unusual interest because of the extraordinary extent of the infection downward, behind the femoral vessels into the thigh, backward, into the pelvis, outward, through the sacrosacral foramen into the gluteal region. The infection following operation for prolapse of the uterus was unusual in that it was bilateral, involving the iliac retroperitoneal spaces on both sides.

Bacteriology—In the cases of unknown etiology the organisms cultured

from the abscesses were *Streptococcus hervechi* and the *Staphylococcus aureus* in two, and *Streptococcus* *faecalis* is not anticipated. In the cases of acute iliac lymphadenitis (bone) abscess *Pseudomonas* *aeruginosa* in three, and *Staphylococcus aureus* in four. In the metastatic abscesses were *Streptococcus hemolyticus* in one, and pneumococcus (Type-19) in one, *Bacillus coli* was the organism in the cases of appendiceal abscess and diverticulitis of the sigmoid. The culture of the perforation of the sigmoid was a mixture of *B. coli*, enterococcus, and *Streptococcus viridans*. Enterococcus was the organism found in the abscess following operation for uterine prolapse. A mixture of enterococcus and *B. coli* was the culture of the abscess of intestinal origin. Thus, as in the lumbar retroperitoneal abscesses, the organisms varied with the source of infection, the *Streptococcus hemolyticus* and *B. coli* organisms predominating.

Clinical Manifestations—The ages of the patients ranged from seven months to 62 years. Two groups occurred only in children—the cases of unknown etiology and the metastatic abscesses. Four of the five cases of acute iliac lymphadenitis were in children. Thus, the iliac type of retroperitoneal suppuration is common in childhood.

All patients complained of pain located in the abdomen (13 cases), and in the lower extremity (ten cases). Abdominal pain was noted either in the lower abdomen (iliac region), or in the inguinal region. The pain in the lower extremity was referred to the hip, thigh, or knee. This was particularly true of abscesses involving the psoas muscle, the referred pain being due to direct irritation of branches of the lumbar plexus.

Fever was noted in the histories of 15 cases, and chills in three cases. The duration of symptoms before admission to the hospital varied from two days to five months, the average period being three to four weeks. In five cases there were preceding traumas, within 48 hours of the onset of symptoms in three cases.

The most common feature of physical examination was tenderness either in the iliac or inguinal regions. A mass was found in these regions in 15 cases and in three other cases an indefinite mass was noted. In seven instances there were positive findings on rectal examination, either a tender fullness or a mass. In one case the only lead was a tender mass felt on rectal examination. The finding of psoas (hip) spasm was an important sign and was present in 11 cases. It should be noted that the signs referred to above were found at some time in the period of observation, but were not always present on admission to the hospital.

Fever was a constant finding during the period of observation, usually between 102° and 103° F., with an associated increase in pulse rate. Leukocytosis and polymorphonucleosis were noted in 18 of the 19 cases in which blood counts were recorded, averaging 19,000 and 82 per cent, respectively. One or more negative blood cultures were reported during the period of observation in five cases in which they were taken. In one of the metastatic

abscesses secondary to mastoid suppuration the blood culture was positive for *Streptococcus hemolyticus*

Diagnosis—In view of the frequency of iliac retroperitoneal abscesses and diseases of the hip joint (acute infectious arthritis and tuberculosis) in childhood, the differentiation between these unrelated lesions becomes at times a problem only insofar as pain in the lower extremity and hip spasm are common to both. As far as the latter is concerned, motion of the hip in iliac abscess is limited to extension, whereas in disease of the hip joint the hip is partially restricted in all directions.

A suppurative lesion was usually suspected because of fever and local tenderness, but the slow evolution of a mass often delayed diagnosis. Operation was sometimes withheld until a mass became evident. As a result the preoperative period of observation ranged from one day to one month. Some of the lesions were found to be in an advanced state of suppuration at the time they came to operation. Therefore, as has been suggested for lumbar retroperitoneal abscess in cases in which a mass cannot be felt, examination under anesthesia may reveal a mass which could not be felt through the plastic lower abdominal wall. Three of the cases of unknown etiology were erroneously diagnosed as acute appendicitis. In two cases, in which the abscesses were in close proximity to the psoas muscle, roentgenograms of the spine revealed a scoliosis in the lumbar region with convexity away from the diseased side.

Treatment and Results—Operation was performed in all cases, in 19 cases the approach was extraperitoneal, and in four cases transperitoneal. The infections, usually appendiceal abscesses, were considered to be intraperitoneal before operation in the cases in which the peritoneum was traversed. This not only reveals the margin of error in diagnosis, but also serves to emphasize the necessity for being prepared for the surprise of encountering an extraperitoneal abscess when an intraperitoneal one is anticipated. Death from peritonitis will be avoided by a careful operative technic to avoid peritoneal contamination should the abscess be encountered inadvertently, or, when the lesion is found to be extraperitoneal before pus is encountered, by a new incision for its extraperitoneal approach. This statement is supported by the fact that there was neither peritoneal infection nor death in the cases in which the peritoneum was traversed.

An inguinal incision was employed in most of the cases of iliac retroperitoneal abscess. This has the advantage of liberal extension laterally and upwards in order to expose more completely a deeply placed abscess or to explore for a suspected one. The incision is placed directly above and parallel to the inguinal (Poupart's) ligament, and traverses the external oblique aponeurosis, the internal oblique muscle, and the transversalis fascia. Thereby, the lateral portion of the inguinal canal is laid open. The peritoneum is stripped, as in the approach to the pelvic ureter, upward and medially away from the iliac fascia.

The need of full operative visualization and adequate drainage, discussed in the management of lumbar retroperitoneal abscess, must be emphasized. Inadequate drainage is prone to be followed by complications and sequelae, as illustrated in Case 6 (to follow). The abscesses lying within, or in close contact with, the psoas muscle, because of their depth and proximity to the external iliac artery, may present difficulties in exposure. Drainage of such an abscess necessitated in one case (Case 6) severance of the psoas muscle. One of the two deaths in this group was attributed to inadequate drainage, as evidenced by continued fever, hip spasm, unhealthy appearance of the wounds, and leukocytosis.

The average period of postoperative hospitalization was four weeks. Although the period of preoperative observation was long in the cases of iliac lymphadenitis, healing after operation was most rapid in these cases.

In this group of 23 cases there were two deaths, a mortality of 8 1/2 per cent. One death, in a child, has been referred to. The second fatality was in a 57-year-old man with an iliac abscess secondary to perforation of an inflamed diverticulum of the sigmoid. Although the abscess cavity was clean, at postmortem examination there were a number of small abscesses in an inflammatory mass involving the sigmoid, omentum, and a loop of ileum.

Ten patients were followed for more than one year after operation, and were well.

COMMENTS ON FIVE ILLUSTRATIVE CASES REPRESENTATIVE OF GROUP A-2*

GROUP A-2—ILIAIC RETROPERITONEAL ABSCESS

Case 6—Trauma. Recurrent acute and chronic iliac retroperitoneal abscesses requiring multiple drainage. Recovery.

COMMENT. An iliac retroperitoneal abscess, preceded by a fall on the back, was drained and healed three months after operation. The abscess recurred following repeated trauma one year and eight months later. Inadequate drainage necessitated a fourth operation in which infection was found anterior, posterior, and mesial to the psoas muscle. For adequate drainage severance of the psoas muscle was required.

Case 7—Foot infection. Suppurative lymphadenitis. Slow evolution of iliac abscess. Drainage. Recovery.

COMMENT. The sequence of events were infection of the foot, lymphangitis and lymphadenitis of femoral, inguinal and iliac nodes, and iliac retroperitoneal abscess. The slow evolution of the abscess, over a period of three weeks, is worthy of note. The retroperitoneal mass was never well defined.

Case 8—Iliac appendiceal abscess. Transperitoneal drainage. Recovery.

COMMENT. This case is classified as an iliac appendiceal abscess because of the clinical manifestations and operative findings, although the appendix

* The details of these cases will be published elsewhere at a later date.

was not seen at operation. Although there was no fecal discharge from the wound, a transient fistula into the cecum was demonstrated by injection of lipiodol.

Case 9—*Perforation of sigmoid. Extensive retroperitoneal infection involving iliac retroperitoneal space, pelvis, thigh and gluteal regions, requiring double drainage and closure of sigmoidal perforation. Recovery.*
COMMENT This case is of interest because of the extraordinary extent of infection secondary to perforation of the sigmoid, not only involving the retroperitoneal space, but the pelvis, thigh and gluteal regions. Multiple incisions, over a period of two and one-half years, were necessary before recovery was effected. The etiology of the perforation was not determined.

Case 10—*Vaginal operation for prolapse of the uterus and cystocele. Bilateral iliac retroperitoneal abscesses. Bilateral drainage. Removal of salpinx. Recovery.*
COMMENT This case is unique, in that the iliac retroperitoneal suppuration was bilateral. The clinical picture at the time of drainage was that of advanced peritonitis. Later observation revealed that tubal suppuration also followed the original pelvic operation.

DIFFUSE RETROPERITONEAL INFECTIONS (PHLEGMON)

The diffuse, phlegmonous, retroperitoneal infections stand out in striking contrast to the previously described localized abscesses. This difference is noted not only in the pathologic and clinical features, but in the operative results.

The reaction of the retroperitoneal tissues to infection was studied experimentally by Meyer,⁹ and the results of these experiments tend to prove that the retroperitoneal tissues are less resistant to the invasion of organisms than the peritoneum. In ten dogs, no deaths occurred from intraperitoneal injections of cultures of *Staphylococcus aureus* and *B. pyocyaneus*, except immediate deaths from toxemia, and in these, three of five had sterile peritoneal cavities, no abscesses developed, and there were no signs of peritonitis. In 15 dogs receiving retroperitoneal injections of the same organisms, one-third of the animals in which staphylococcus was used developed abscesses, and three-fourths of those in which pyocyaneus was used developed abscesses, all of whom died.

Pathogenesis—There were 17 cases of diffuse retroperitoneal infection. The sources of infection were as follows: Appendix (six cases), kidney (two cases), ileum (two cases), colon (one case), pancreas (one case), uterus (one case), esophagus (one case), spine (one case), ischio-rectal infection (one case), and unknown (one case). In contrast to retroperitoneal abscesses, in which the etiology was unknown in one-third of the cases, the source of infection could almost always be stated.

The type of lesion in the six cases of appendiceal origin was perforated gangrenous appendicitis in five cases, and phlegmonous appendicitis in one case.

In four cases the appendix was described as retrocecal, and in two cases retrocecal and retroperitoneal.

Abscesses of the kidney were the lesions of renal origin. The remaining pathologic conditions were as follows: Advanced regional ileitis, with perforation, carcinoma of the descending colon, with perforation, acute necrotizing pancreatitis, postabortive endometritis and parametritis, traumatic perforation of the distal end of the esophagus, osteomyelitis of the lumbar vertebrae, and infected wound of the ischiorectal region.

Pathology.—The essential pathologic picture of diffuse retroperitoneal infections is a phlegmonous or necrotizing inflammation, without walling off of the retroperitoneal tissues. This is represented by fibrinopurulent necrotic exudate and small collections of pus. The most striking features of these diffuse infections are the extent of spread and the ill-defined margins.

In all instances the lumbar retroperitoneal tissues were involved. Infection reached the diaphragm in 11 patients, forming subdiaphragmatic abscesses in three cases. In three patients the spread of infection continued above the diaphragm. This upward spread involved the posterior mediastinum (three cases), the pleura (one bilateral) (two cases), and the pericardium (one case).

The infection involved the iliac retroperitoneal tissues in 11 instances. In three patients the infection continued downwards, involving the thigh in two cases, and the inguinal, scrotal and ischiorectal regions in the remaining case. The pelvic retroperitoneal tissues were involved in four cases.

Bacteriology.—*Bacillus coli* was the predominating organism. In seven cases it was found alone, in combination with staphylococcus in one, enterococcus in one, enterococcus and *Clostridium welchii* in one, enterococcus and *B. proteus* in one, and *B. pyocyaneus* and nonhemolytic *Streptococcus* in one. A combination of enterococcus and Friedlander bacillus was found in one case. *Streptococcus hemolyticus* was the organism in one case.

Clinical Manifestations.—The ages of the patients varied from 20 to 62 years, and the infection is thus a lesion of adult life. The symptoms at the onset were those of the underlying disease. In the cases of appendiceal origin, the unusual features were right upper quadrant abdominal pain and chills in two cases. Lumbar pain, chills, and fever were the symptoms in the cases of renal origin. In the cases in which there was extension of infection to the thigh and scrotum, there was pain in these regions.

The outstanding symptoms in the patients with regional ileitis were abdominal pain and fever in one, and pain in the hip radiating down the thigh in the other. The symptoms in the other cases were as follows: Carcinoma of the colon. Lumbar pain and fever. Pancreatitis. Generalized abdominal pain and vomiting. Parametritis. Pain in the back, chills, and fever. Perforation of the esophagus. Epigastric pain, chilliness, fever, dyspnea, and cough. Osteomyelitis of the lumbar vertebrae. Lumbar pain and fever. Ischiorectal infection. Lower abdominal pain, fever, chills, and vomiting. Unknown etiology.

Abdominal pain and distention, fever, and chills. Thus in only one-fourth of the cases did the symptoms suggest a retroperitoneal infection.

The duration of symptoms varied from one day to ten weeks. The period was less than one week in five cases of appendicitis and in the cases of carcinoma of the colon, pancreatitis, perforation of the esophagus, and ischiorectal infection. The duration of symptoms was longest in the cases of ileitis, in those of renal origin, and in the osteomyelitis of the lumbar vertebrae.

The findings on physical examination were usually those of the underlying disease. Occasionally, signs were present which suggested retroperitoneal infection. Thus, in the cases of appendicitis, lumbar tenderness was noted in three patients, and a tender lumbar mass in one patient, tender lumbar masses in the cases of renal origin and carcinoma of the colon, lumbar tenderness in the case of parametritis. Often, however, signs of retroperitoneal infection were absent. In the cases in which there was extension of infection to the thigh, scrotum, and ischiorectal region there were signs of suppuration in these areas. Abdominal distention was a frequent finding. Psoas (hip) spasm was noted in four patients, in the cases of ileitis, in one case of renal origin, and in the instance of osteomyelitis of the lumbar vertebrae.

Fever was a constant finding during the period of observation, usually above 102° F, with an associated increase in pulse rate. Leukocytosis and polymorphonucleosis were present in 12 of the 14 cases in which blood counts were recorded, averaging 16,000 and 83 per cent, respectively. One or more negative blood cultures were reported during the period of observation in eight cases in which they were taken. The blood cultures were positive in two cases—*B. coli* in one case of renal origin and *Streptococcus hemolyticus* in the case of ischiorectal infection.

Diagnosis—There were two general features which could be regarded as suggestive of a diffuse retroperitoneal infection. First, the patients were ill out of proportion to the manifestations ordinarily referable to the causative infective focus, and second, pronounced abdominal distention was common. The diagnosis of a retroperitoneal infection was not made in 11 cases. In the six cases in which the diagnosis was made the extent of infection was not realized. Thus, in the cases of appendiceal origin, the diagnoses were acute appendicitis in three, appendiceal abscess in one, acute cholecystitis in one, and perinephric abscess in one. Retroperitoneal infection was not considered in the cases of pancreatitis, parametritis, ischiorectal infection, in one case of ileitis and in the case of unknown etiology. In addition to the cases of renal origin the diagnosis of retroperitoneal infection was made in the cases of perforation of the esophagus, carcinoma of the colon, osteomyelitis of the lumbar vertebrae, and in one case of ileitis. The periods of preoperative observation were short. Under 24 hours in five, 24 to 48 hours in five, two days in one, eight days in one, 12 days in one, and 16 days in one.

Treatment and Results—Operation was performed in 14 cases. The operative approach was usually for the underlying disease: transperitoneal, in five cases of appendiceal origin, in one case of ileitis, and in the cases of pancreatitis, perforation of the esophagus, and in the case of unknown etiology; extraperitoneal, in the cases of renal origin, in one case of ileitis, in the carcinoma of the colon, and in the osteomyelitis of the lumbar vertebrae. In the cases in which there was spread of infection to the thigh, scrotum, and ischiorectal region, additional incisions were made in those regions.

In this group of 17 cases there were 17 deaths, a mortality of 100 per cent. The duration of life after operation was as follows: Under 24 hours in three, 24 to 48 hours in four, four days in one, five days in one, six days in one, two weeks in one, four weeks in one, and seven weeks in two. The period of hospitalization in the three fatal unoperated cases was 30 hours in one patient and four days in each of two patients.

The primary cause of mortality was the extent of infection which precluded adequate drainage, such as spread of infection to the posterior mediastinum, pericardium, root of the mesentery of the small intestine, and bilateral infections. In cases in which such spread did not take place the infections often extended from the diaphragm downward through the lumbar and iliac retroperitoneal tissues. Infections of appendiceal origin should offer a better prospect for recovery. The diagnosis is usually made early and the infection can usually be adequately drained, although this was not true of the cases in this series, the extent of infection found at postmortem examination being greater than that which existed at the time of operation. In two cases peritonitis and abdominal wall infection, which did not exist at the time of operation, contributed to the fatal issue. The type of drainage is very important, namely, drainage by gauze placed as a packing to the limits of the infection. The experience with sulfonamide drugs was limited to three cases in this group, but their administration did not influence the course of the disease.

COMMENTS ON FIVE ILLUSTRATIVE CASES
REPRESENTATIVE OF GROUP B*

GROUP B—DIFFUSE RETROPERITONEAL INFECTIONS (PHLEGMON)

Case 11—Retroperitoneal appendiceal abscess. Drainage. Retroperitoneal phlegmon. Death.

COMMENT: The patient presented a retroperitoneal appendiceal abscess at operation. The institution of adequate drainage (see Case 4) might have resulted in recovery. The extent of infection found at postmortem examination was greater than at operation.

* The details of these cases will be published elsewhere at a later date.

Case 12 — *Abscesses of kidney, with retroperitoneal phlegmon Drainage Death*

COMMENT This case illustrates the rapid spread of a phlegmonous retroperitoneal infection to the scrotum, perineum and ischiorectal region

Case 13 — *Regional ileitis, with retroperitoneal abscesses and phlegmon Multiple drainage Death*

COMMENT The earliest manifestation of advanced regional ileitis (except for occasional diarrhea) was a retroperitoneal abscess secondary to perforation of the ileum The abscess was one of several, and there was a phlegmonous inflammation in both retroperitoneal spaces which extended downward into the pelvis on both sides, passing through the greater sciatic notches into the gluteal regions and thighs

Case 14 — *Carcinoma of colon, with retroperitoneal abscess and phlegmon Drainage Death*

COMMENT The patient had a carcinoma of the descending colon, with perforation, resulting in a retroperitoneal abscess and phlegmon The retroperitoneal infection was bilateral

Case 15 — *Endometritis and parametritis, with retroperitoneal phlegmon No operation Death*

COMMENT This is a case of phlegmonous retroperitoneal infection derived from a suppurative endometritis and parametritis, with rapid evolution of the infection and death

SUMMARY AND CONCLUSIONS

A study of acute retroperitoneal infections has been based on an analysis of 65 cases These infections have been classified as abscesses occurring in the lumbar or iliac regions and phlegmonous inflammations diffusely spread in the retroperitoneal tissues There were 25 lumbar abscesses, 23 iliac abscesses, and 17 diffuse infections

Acute retroperitoneal infections are always secondary The infection is derived by direct extension from suppuration in an adjoining organ, by lymphatics, and by metastasis from distant foci of infection The etiology was not determined in one-third of the abscesses, whereas the source of diffuse infections could almost always be stated Trauma appeared to play a definite rôle in causation in 15 per cent of the abscesses The most common source of diffuse infections was acute appendicitis (35 per cent)

There is a marked contrast between the pathologic features of abscess and phlegmon of the retroperitoneal tissues The former is well-localized and the latter is represented by fibrinopurulent or necrotic exudate and small collections of pus, with a tendency to spread beyond the confines of the retroperitoneum

The bacteriology varied with the source of infection, the *Staphylococcus aureus*, *Streptococcus hemolyticus* and *B coli* predominating in the abscesses and the *B coli* alone or in combination, in the diffuse infections

Iliac abscesses occur more frequently in childhood—61 per cent of the cases in this study

A history of pain and fever was common to all patients with retroperitoneal abscesses. Pain in the lower extremity was noted in about one-half of the cases of iliac abscess particularly abscess involving the psoas muscle. The symptoms in the diffuse infections were masked by those of the underlying disease, and in only one-fourth of the cases did symptoms suggest a retroperitoneal infection. Tenderness in, and spasm of, musculature in the region of abscesses was a common feature associated with a mass in 65 per cent of the cases. Abdominal examination revealed a mass in one-half of the cases of lumbar abscess. Psoas (hip) spasm was noted in one-half of the cases of iliac abscess.

A suppurative lesion was usually suspected, but the slow evolution of a mass often delayed the diagnosis of retroperitoneal abscess. Operation was sometimes withheld until a mass became evident, some of these lesions were found to be in an advanced state of suppuration at operation. Examination under anesthesia is suggested in cases in which muscle spasticity exists and interferes with the palpation of a mass. There were two general features suggestive of diffuse retroperitoneal infections, toxicity and abdominal distention. The diagnosis of retroperitoneal infection was not made in 65 per cent of the cases of diffuse infection and in the cases in which the diagnosis was made the extent of infection usually was not realized.

The operative approach was extraperitoneal in 83 per cent of the abscesses, and in the cases in which the peritoneal cavity was traversed the diagnosis of a retroperitoneal abscess had not been made before operation. A careful operative technique will avoid peritoneal contamination should the abscess be encountered inadvertently, or when the lesion is found to be extraperitoneal before pus is encountered, by a new incision for its extraperitoneal approach. The need of full operative visualization and adequate drainage is emphasized and the details of operative technique are discussed.

There was a wide difference in the operative mortality of abscesses and diffuse infections—8 per cent in abscess and 100 per cent in diffuse infection. The primary cause of death in diffuse infections was the extent of infection which precluded adequate drainage.

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ANNULAR PANCREAS PRODUCING DUODENAL OBSTRUCTION

REPORT OF A SUCCESSFULLY TREATED CASE

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THIRLI has recently come under our care a newly born infant with evidence of duodenal obstruction, which was proved to be due to an annular pancreas. Operation on the third day of life has brought about complete relief of the baby's symptoms. Both the rarity of this congenital abnormality and its successful correction by surgical means have prompted us to make the following presentation.

Case Report—S. M., a three-day-old female infant, was referred to the Children's Hospital by Dr. Dorothea Mootz on September 16, 1942, because of persistent vomiting of two days' duration. During the mother's pregnancy there had been a moderate hydramnios. The infant was delivered at full term after a short, uncomplicated labor. The birth weight was 5 lbs. 12 oz.

Four hours after birth the baby passed a normal-appearing meconium stool. Shortly after this she vomited. During the remainder of the first 24-hour period there was vomiting on four occasions. At no time was the vomitus bile-stained. On the second day the baby was put to the breast and suckled well, but there was projectile vomiting of curdled milk after each nursing. Again, there was no bile staining. Two meconium stools were passed. On the third day of life, the course was essentially the same, and was characterized by repeated vomiting and by the passage of only a small amount of meconium by rectum.

Physical examination on entry showed a small but normally developed infant, as far as external appearances were concerned. Temperature 100.4° F. Pulse 140. Respirations 30. There was slight dehydration. The upper abdomen, while not greatly distended, was distinctly more prominent and tympanitic than the lower abdomen, which was flat and soft. Large peristaltic waves, apparently gastric in origin, could be seen running across the epigastrium from left to right. No abnormal masses could be palpated. On auscultation, no abnormal peristalsis could be detected.

Röntgenologic examination of the abdomen, with the child in the recumbent position, showed some dilatation of the stomach, and a bubble of gas in the right upper quadrant of the abdomen which was assumed to be air in a dilated first portion of the duodenum (Fig. 1). No gas could be found in any other part of the abdomen. These findings were interpreted as representing a complete obstruction of the duodenum. A barium meal was not given. It was felt that the diagnosis of duodenal obstruction was sufficiently established to warrant surgical exploration without further investigation.

Operation was undertaken after infiltrating the anterior abdominal wall with 0.5 per cent procaine hydrochloride. During the procedure the child was allowed to suck on a nipple containing sugar water and brandy. A long, right rectus incision was made, retracting the muscle belly laterally. Upon opening the peritoneum, about one ounce

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of the stored fluid escaped. The first part of the duodenum was strikingly dilated to five times its normal size. This enlargement extended downward to the second part of the duodenum, which was markedly constricted by a ring of pancreatic tissue which completely surrounded the duodenum and which was continuous with the head of the pancreas (Fig 2). Below this site the small intestine was quite collapsed and was no more than 5-6 Mm in diameter. Since a few bubbles of gas could be felt



FIG 1—Roentgenogram of three day old baby with duodenal obstruction from annular pancreas. Note gas in the stomach and in the dilated first portion of the duodenum. No gas seen in remainder of abdomen.

in this tiny intestine, it was thought that the duodenal obstruction was not a complete one. However, the lumen at its constricted area was certainly no more than a millimeter or two in diameter. The gallbladder, hepatic duct, and upper portion of the common duct were normal in appearance and were not distended. It was, therefore, felt that the lower end of the common duct was not obstructed, even though this structure could not be fully traced behind the duodenum and its relationship to the ring of pancreatic tissue could not be determined. There was an incomplete rotation of the colon, the cecum and appendix lay in the midepigastrium, while the exposed duodenum ran directly

down the right paravertebral gutter to join the jejunum. This state of affairs made it quite easy to examine the annular portion of the pancreas as well as the duodenum above and below it. Likewise, the incomplete rotation of the colon greatly facilitated the subsequent operative procedure since the colon was out of the way and did not enter into the local operative field.



FIG. 2.—Drawing of anatomic abnormalities found at surgical exploration. Continuous with the body and head of the pancreas is a ring of pancreatic substance which completely surrounds and obstructs the duodenum. First portion of duodenum is dilated. Beyond the obstruction, the intestine and colon are collapsed. The colon is incompletely rotated.

At first sight, it appeared that the logical attack on the abnormality would be to sever the ring of pancreatic substance, or to resect a portion of the same in order to free the underlying duodenum. Such a plan was rejected because there was no way of telling whether important pancreatic ducts ran through the anterior and available part of the ring. Division of such ducts might interfere with discharge of external secretions of the pancreas into the duodenum, or, indeed, a transection of such ducts might give rise to a troublesome pancreatic fistula. Furthermore, there was no assurance that severance of the pancreatic ring would necessarily allow the constricted portion of the duodenum to dilate since this latter structure might still have an intrinsic stenosis which would require vertical incision of the narrowed duodenum and transverse suture of this wound (Heineke-Mikulicz procedure). Such a plastic repair did not appear to be an inviting form of therapy because it has been our experience in the past that a direct attack on any congenital stenosis or atresia of the alimentary tract is

seldom as satisfactory as a short-circuiting operation by a side-to-side anastomosis. It was, therefore, decided to let the local abnormality completely alone and to perform a side-to-side duodenojejunostomy. Accordingly, the jejunum was brought upward and laid against the anterior wall of the dilated first portion of the duodenum so that an isoperistaltic type of anastomosis could be established. This was completed with two layers of continuous silk (No 00000 Deknatel) on an atraumatic needle, making a stoma about three cm. in length. When this union had been completed, gas readily passed from

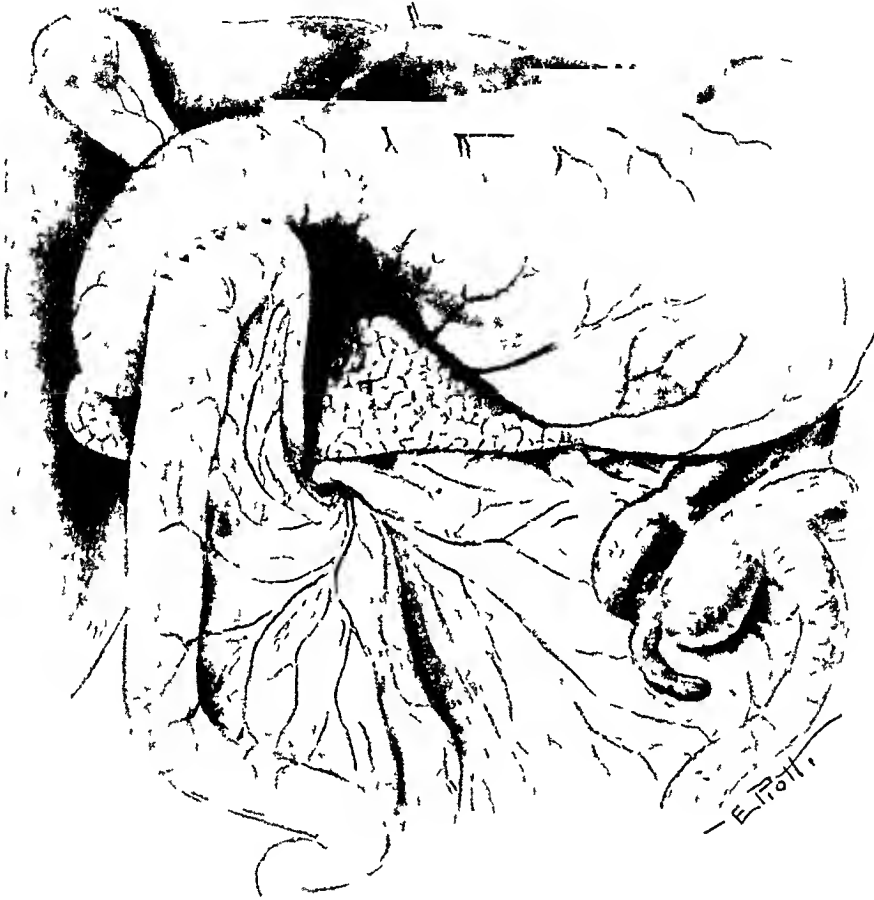


FIG 3—Method of surgical alleviation of duodenal obstruction by establishment of an isoperistaltic duodenojejunostomy

the duodenum into the jejunum. Simultaneously, the first portion of the duodenum diminished to a more normal size, while the jejunum and ileum began to dilate (Fig 3). The abdomen was closed without drainage. The peritoneum was closed with No 000 continuous chromic catgut, all of the remaining layers were brought together with interrupted silk sutures of No 00000 Deknatel.

Postoperatively, the patient was not placed on constant gastric suction. Instead, the stomach was lavaged every six hours for the first postoperative day. During the second postoperative day whey was offered every three hours. On the third day breast milk was given every four hours. This was increased in amount until the child was obtaining normal caloric requirements by the sixth day. Sodium sulfadiazine was given by parenteral routes for the first three days after operation. The skin sutures were removed on the sixth day and the wound healed *per primam*. The baby was discharged from the hospital

on the sixth postoperative day. There was no vomiting, she was taking her feedings well, and she was beginning to have stools which contained curds.

Subsequent development of this child has been quite normal. She has consistently taken feedings eagerly and satisfactorily, her diet has not been restricted in any way. The weight gain has been satisfactory. There have been no symptoms or signs of duodenal obstruction at any time. When last examined at 16 months of age the child weighed 23 lbs. (Fig. 4).



FIG. 4.—Photograph of patient at 16 months of age, showing satisfactory development and nutrition.

ABNORMAL ANATOMY—PATHOLOGY

In this malformation the head of the pancreas lies in its customary position in the bend of the duodenum. From this head two arms of pancreatic tissue extend around the second part of the duodenum, one anteriorly and one posteriorly. These usually fuse to form a complete encircling mass, but if a gap occurs between the two ends it is apt to appear anteriorly. Such a ring of pancreatic substance almost invariably produces, or is accompanied by, some degree of constriction in the duodenum. If this blockage is minimal, there is little or no associated evidence of intestinal obstruction. If, however, the constriction is marked, the proximal duodenum is dilated and its wall is hypertrophied. In only rare instances is there an atresia of the duodenum at the level of the pancreatic ring.

The annular portion of pancreatic substance has all of the histologic characteristics of a normal pancreas. It contains islet as well as acinar tissue. The ducts for the external secretions have been the subject of considerable investigation. They may be rudimentary and may run from the anterior part of the ring towards the left to join the main pancreatic duct. However, it is more customary for the annular part of the pancreas to be traversed by a major duct which begins anteriorly, runs to the right, and then curves around laterally and posteriorly, finally, to join either the common bile duct or the main pancreatic duct. In some of these cases the lower portion of the common duct passes through the posterior portion of the annular pancreas and is obstructed either by constriction or angulation.

The pathologic data can be divided into four general categories: (1) The changes which occur in the pancreatic substance itself, (2) the secondary effects upon the alimentary system, (3) the derangements which are sometimes found in the lower biliary passages, and, finally, (4) the associated congenital abnormalities in other portions of the body.

Numerous writers have commented upon the findings of some form of pancreatitis, either acute and hemorrhagic in nature or chronic and cicatricial in type. Such changes may involve the main body of the pancreas, only the annular portion, or the entire pancreatic substance. Severe pancreatitis is not infrequently the illness which brings the individual to the operating table or to autopsy. The relatively high incidence of inflammatory lesions in patients with an annular pancreas certainly suggests a causal relationship to the abnormal form of the ducts. Certainly, it is conceivable that an attenuated or compressed ductal system could produce stasis and subsequent back pressure effects. Similarly, a direct communication with the common bile duct, associated with compression of the lower portion of the common duct, might lead to reflux of bile into the pancreatic system and thereby activate the pancreatic enzymes.

The secondary changes in the intestinal tract are obvious. The evidence of dilatation and thickening of the first part of the duodenum are in direct proportion to the degree of constriction which the annular pancreas produces. Gastric or duodenal ulceration has been frequently reported. This may be dependent upon stasis of gastric or intestinal contents or it may possibly be secondary to a reduced flow of pancreatic juices.

Any disturbances in the biliary system, if they occur, are purely those brought about by compression of the common bile duct as it traverses pancreatic tissue. Dilatation of the extrahepatic biliary system, stasis of bile within the liver, and evidence of icterus throughout the body may be of variable and even of marked degree. If such biliary obstruction supervenes, it is apt to be manifest in infancy or early childhood.

Finally, like any congenital malformation in the human, an annular pancreas may be associated with a considerable incidence of other anatomic abnormalities in regional or distant parts of the body. However, these are often of only academic interest and do not necessarily disturb the patient's health.

Indeed, they are frequently not suspected or discovered until exploratory celiotomy or autopsy examination. In the case herewith reported there was an incomplete rotation of the colon, which in no way interfered with the functioning of the alimentary system.

EMBRYOLOGY

Embryology of the annular pancreas has been thoroughly discussed by McNaught,¹⁰ and others. Theoretic explanations of the anomaly are mainly twofold. Lerat,⁹ Weissberg,¹⁵ and others, contend that the annular arrangement is merely the result of hyperplasia—this is, overgrowth of pancreatic substance, dissecting in such a way beneath the serosal coat of the duodenum that it finally surrounds this part of the alimentary tube. They suggest that such an enlargement follows fetal peritonitis as a regenerative process. Most workers, however, favor the theory that the malformation results from the failure of the tip of the ventral pancreatic anlage to rotate with the duodenum—as does its ductal outlet. In consequence, a band of elongated, pancreatic tissue becomes wrapped around the duodenum in a napkin-ring fashion and the duct from the ventral anlage sweeps around the entire duodenum to enter the duct of Wirsung.

CLINICAL DATA

In 1933, McNaught¹⁰ reviewed the literature and collected 40 cases of annular pancreas. In 1935, he and Cox¹¹ presented an additional case and cited three others which had been already recorded. In 1942, Lehman⁸ brought this total up to 48 cases, and particularly emphasized the clinical problem which can result from this congenital abnormality. In 1943, Chapman and Mossman³ described the findings in a dissection room subject. This, together with our patient, now brings the number to at least 50 reports of annular pancreas in man.

Out of the above-indicated 50 examples of annular pancreas, 39 were incidental postmortem findings with little or no history of difficulty during the lives of the patients. Only 11 of the 50 subjects had complaints which led to clinical study and eventually to surgery. These are summarized in Table I. Vidal's patient, and also ours, were three days old. The age of the remaining nine varied from 26 to 74 years. It is, therefore, evident that the duodenal obstruction can be complete (Vidal's), or nearly complete (our case), so that there is evidence of duodenal obstruction in the first few days of life. Conversely, the degree of obstruction may be so slight that no complaints are referable to it until subsequent years or even adult life.

When an annular pancreas has been productive of symptoms it usually manifests itself in the form of acute or recurrent duodenal obstruction (ten of 11 cases). Hence, there may be epigastric pain, nausea, vomiting, and possibly malnutrition. The vomitus may or may not contain bile, depending upon the anatomic relationship of the common bile duct exit to the narrowed

TABLE I

CASES OF ANNULAR PANCREAS TREATED BY OPERATION

Case	Reported by	Age—Sex	Operation	Result	Remarks
1	Vidal 1905	Male 3 days	Posterior gastro enterostomy	Cure	Also had congenital atresia of duodenum
2	dos Santos 1906	Female 26 yrs	Posterior gastro enterostomy	Died (pneumonia)	Had chronic interstitial pancreatitis
	Lerat 1908	Female 46 yrs	Resection of pancreatic ring	Cure	Drainage ceased on 13th day
4	Smetana 1928	Male 74 yrs	Posterior gastro enterostomy	Died	Marked fibrosis of pancreas Ca of cystic duct
5	Howard 1930	Female 46 yrs	Division of ring	Cure	Pancreatic fistula requiring second operation
6	Brines 1930	Male 35 yrs	Drainage of pancreatitis	Died	
7	Zech 1931	Female 27 yrs	Division of ring Heineke-Mikulicz plastic on duodenum	Cure	Small pancreatic fistula
8	Brines 1931	Male 44 yrs	Posterior gastro enterostomy	Died (respiratory infection)	
9	Truelsen 1940	Male 35 yrs	Posterior gastro-enterostomy Plastic on duodenum	Cure	
10	Leliman 1942	Male 23 yrs	Partial resection of ring	Recovery but persistent symptoms	
11	Gross & Chisholm 1944	Female 3 days	Duodenojejunostomy	Cure	

portion of the duodenum. Roentgenologic examination by a barium series should give rather conclusive proof of a partial block, with dilatation of the first part of the duodenum compared to a more collapsed third part of the organ. The midduodenum is notched or constricted. Such filling defects, and associated delay in emptying of stomach and first part of the duodenum may be indistinguishable from the picture produced by a healed duodenal ulcer which has given rise to marked duodenal deformity. However, in a subject of childhood years, such roentgenologic findings would be more suggestive of a congenital abnormality than of a peptic ulcer.

In occasional cases the symptomatology and physical findings are those resulting from acute pancreatitis. Severe abdominal pain, distention, marked tenderness, rapid pulse and rising temperature may indicate a severe and diffuse inflammation of the organ, without giving any clue regarding the underlying abnormality which probably has precipitated this condition. Indeed, operation has been performed for hemorrhagic pancreatitis and the anatomic structures have been so distorted and obscured by the inflammatory process, that the anomalous form of the pancreas was overlooked until subsequent postmortem study.

In rare instances, usually in infants dying within the first few months of life, jaundice has been the presenting complaint. It may be mild or marked. The stool contains much or little bile pigment—depending upon the degree of obstruction of the biliary passage. In one instance studied in the Children's Hospital pathology laboratory by Dr. Sidney Farber (to be subsequently reported) the common duct was completely blocked, the stools were acholic and the baby had a very high icteric index prior to its death at five months.

TREATMENT

Aside from those individuals with pancreatitis, or possibly with biliary obstruction, the necessity for operation will naturally depend upon the degree of existing duodenal obstruction and the severity of the attendant symptoms. Under rare circumstances the duodenum may be atretic (Vidal) and surgical relief is imperative in the first few days of life. Similarly, in our case, the tiny, pinhole opening representing the duodenal lumen induced a nearly-complete block and required early operative intervention. It has been more typical however to find that a fluid or even solid diet could be tolerated for many years before symptoms of high intestinal obstruction manifest themselves and necessitate relief.

The alleviation of duodenal obstruction could be conceivably effected in three different ways and each type of operation has been supported by various proponents.

- 1 *Division of the ring of pancreatic tissue* or a resection of part of the same, has been performed by Leiat Howard and by Lehman. Zech followed this procedure by a Heineke-Mikulicz type of plastic enlargement of the constricted duodenal wall. All of these patients survived, but three of them developed a pancreatic fistula which gave some concern during the post-operative course. While only one of these required a secondary operation for closure of the fistula, it is well to point out that such pancreatic leakage is a distinct hazard in this type of operation. Since the pancreatic ducts may exhibit considerable variation in their distribution, the operator can never be certain when a major duct will be severed if the pancreatic ring is divided. Furthermore, simple section (or partial resection) of the ring will not always insure a complete release of the duodenum, since the latter may be constricted by intrinsic scar tissue within its wall. A review of the available cases treated by these methods leads to the distinct impression that direct attack on the pancreatic ring or constricted portion of the duodenum is inferior to a short-circuiting type of operation.

- 2 *A posterior gastro-enterostomy* was established by Vidal, dos Santos, Smetana, and by Bimes. It was combined with a plastic repair of the duodenal wall by Truelsen. Two of these patients were cured and three succumbed. This high mortality rate should not necessarily condemn the operation, since the fatalities were due to unrelated causes. Relief of the duodenal obstruction by gastro-enterostomy will probably have the largest number of adherents, since this operation is a well standardized one and will undoubtedly relieve symptoms in the majority of instances. However, it is possible that in some cases it would not effectively drain the proximal duodenum.

- 3 *Duodenojejunostomy* has been established in only one case—the one here reported. We believe this to be the ideal type of surgical correction, because it completely relieves the duodenal obstruction, does not interfere in any way with the gastric functions, and does not possess any of the hazards of cutting the pancreatic ring with its attendant danger of a fistula. Ladd⁷

has repeatedly emphasized the value of duodenojejunostomy for congenital atresia or stenosis of the duodenum, such a short-circuiting type of operation seemed ideal for our patient with a duodenum obstructed by an annular pancreas. An isoperistaltic duodenojejunostomy was completed in our case with ease, in spite of the diminutive size of the distal collapsed loop of intestine. It was, of course, greatly facilitated by the congenital incomplete rotation of the colon (which made the duodenum more approachable) but the presence of a normally situated colon would not be a serious obstacle to completion of the anastomosis. After performance of this repair in our case, and being highly satisfied with the result obtained, a perusal of the literature shows that Zech, and more recently Lehman, had formerly concluded that duodenojejunostomy would be the operation of choice for these patients.

SUMMARY AND CONCLUSION

A case is reported of a newly-born infant with duodenal obstruction due to an annular pancreas. This was treated on the third day of life by a duodenojejunostomy with complete success. Pertinent facts taken from the literature regarding this congenital abnormality are briefly reviewed. The constriction of the duodenum is not always sufficient to cause clinical symptoms. If symptoms of duodenal obstruction appear, they should be relieved by surgical correction. Operative alleviation of the obstruction has been practiced by (1) Division of the pancreatic ring—with or without a plastic procedure on the duodenal wall (2) Posterior gastro-enterostomy (3) Duodenojejunostomy. We believe that the first procedure is the least desirable and that the last one is the operation of choice. The case herewith described is the only one which has ever been treated by this method.

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THE CONSERVATIVE TREATMENT OF ACUTE DUODENAL FISTULA*

CASE REPORT

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A PROFUSELY DRAINING DUODENAL FISTULA is a serious and disconcerting complication of certain types of upper abdominal surgery. It carries an exceedingly high mortality rate, variously reported as from 27 to 60 per cent, or an average mortality rate including all forms of treatment of 36.0 per cent.³ Duodenal fistulae may be classified into two main groups: (1) The lateral type, in which an opening develops in the wall of the duodenum, with the continuity of the gastro-intestinal tract intact, as follows: gall-bladder surgery, repair of perforated peptic ulcer, *etc.*, and (2) the end type, following the surgical closure of the amputated duodenal stump in gastric resection.¹

The outstanding principles of therapeutics advocated in the treatment of this disease have been: (1) jejunostomy and jejunal feedings, as described by McGuire and Erdman, (2) suction, as introduced by Carmen, Lahey, Potter, *etc.*, (3) neutralization of the intestinal juices as advocated by Potter, and (4) the blood chemistry changes, as demonstrated by various authors.

Acute postoperative duodenal fistulae have been reported in the literature in approximately 130 patients, and to this group we wish to add another case which made a remarkable recovery on a conservative plan of therapy.

Case Report—Harper Hosp., No. 248275. A 64-year-old white male was admitted, March 28, 1943, with a history of gradual, painless jaundice of two months duration, clay-colored stools, weight loss and dark urine. In February, 1941, he had undergone a transurethral resection of the prostate and the removal of a diverticulum of the urinary bladder and, in July, 1942, a cholecystectomy and common duct drainage. Physical examination revealed a moderate jaundice, a slightly enlarged liver, atrophy of the small muscles of the hands, and glossitis. Laboratory data: Hb 67.0 per cent, RBC 3,620,000, WBC 8,500, urine loaded with pus, blood N/CN 29.0 mg, icteric index 30, and a prothrombin time of 90 per cent. *Preoperative Diagnosis*: Postoperative stricture of common duct, rule out carcinoma of the head of the pancreas.

Exploratory celiotomy, April 6, 1943, disclosed a stricture of the common duct where it passed behind the first portion of the duodenum. A longitudinal incision was made through the wall of the common duct at the stricture and closed transversely over a T-tube to enlarge the diameter of the duct. During this procedure the duodenum was torn by a Deaver retractor. It was immediately repaired with catgut and covered with a tab of omentum.

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During the third postoperative night there occurred a profuse, greenish, bile-stained and foul-smelling mucus discharge from the wound. The discharge continued to increase in amount and Wangenstein suction with a Levine tube was started in an attempt to advance the tube through the duodenum and beyond the perforation. This procedure was unsuccessful and was discontinued. The discharge macerated the skin, digested the wound, and seriously dehydrated the patient. A suction unit, of my construction, for draining sinuses was placed in the wound and all the drainage was collected before it reached the skin surface (Fig 1). An attempt was made to refeed the secretions



FIG 1—Photograph of the patient with the drainage unit inserted into the healing duodenal fistula. The jejunostomy tube is closed with a clothespin, and lies to the patient's left.

Insert—A pyrex glass model of the drainage unit, with a piece of string entering the 'U' arm and leaving the tube, the course of aspirated fluids. A removable rubber cap at the opposite end enables one to clean the tube easily.

or administer them in the form of retention enemata. The patient, however, was entering a state of alkalosis which would soon become irreversible. On April 15, 1943, under local anesthesia, Witzel jejunostomy was established, and for the next 40 days he received the collected drainage from the fistula through this tube. On the 50th postoperative day the duodenal fistula had closed spontaneously and the jejunostomy tube was removed. On the 65th postoperative day he was discharged, completely healed.

A follow-up examination six months later found the patient looking very well, having gained 40 lbs in weight and presenting no complaints, except a medium-sized incisional hernia for which he wears a support. There has been no jaundice, clay-colored stools or epigastric pain.

COMMENT—The etiology of this type of lateral duodenal fistula is usually the unrecognized trauma at operation, resulting in the devitalization of the tissue followed by spontaneous perforation. Damage in our case was caused by a Deaver retractor, and the immediate repair of the rent subsequently broke down. The onset of this complication is acute and is often heralded by a state of shock, in which the patient becomes pale, cold, clammy, apprehensive and covered with beads of perspiration. The drainage from the duodenum is acid, foul-smelling, greenish to black seromucus containing food particles and having an acid reaction.

The drainage attacks and digests the skin, resulting in a red, painful rash and ultimately extensive ulceration. The skin can be protected by an adhesive ointment made as follows:

R Aluminum powder		ounces 3
Zinc oxide		ounces 6
Petrolatum	qs ad	ounces 8

This was applied widely about the wound twice a day, and added to the comfort of the patient.

To control the fluid discharge, a metal drainage unit, a modification⁴ of the McCollum tube, was inserted into the wound to collect the secretions. This unit is so constructed that continuous suction draws the secretions through the perforation on the inner angle of the U-arm and keeps the discharge from welling-up on the skin surface. The hole is protected by the arms of the U and does not become plugged with tissue from the wound edges. The total collected drainage at first amounted to 3000 cc., or more, a day, and consisted of fluids taken by mouth, gastric secretions, bile and regurgitated pancreatic juice.

The jejunostomy tube permitted the free injection of the fistulous drainage directly into the intestinal tract, where it could be best utilized by the body. Also, supplementary tube feedings of a 3000-calorie fluid diet containing 80 units of protein and adequate vitamins was administered three times a day in amounts of 6 to 8 ounces, or more, depending upon the comfort of the patient. This diet contained approximately 40 calories per ounce and the formula was as follows:

Milk	1000 cc
40 per cent cream	400 Gm
Eggs	6
Orange juice	300 Gm
Lemon juice	200 Gm
Sugar	100 Gm
Brewers yeast	5 Gm

A progressive high protein diet was given the patient by mouth, beginning with a soft diet and gradually adding solid food until a full diet was reached.

The plan was to increase the viscosity of the gastric contents by utilizing the capacity of proteins to absorb water and to fix the hydrochloric acid. The more viscous the duodenal contents, the less apt they were to escape through the perforation. Secondly, food by mouth increased the confidence and feeling of well-being of the patient.

The blood chemistry, including the nitrogen level, carbon dioxide combining power, chlorides and protein values, was carefully followed, and all parenteral therapy was given to maintain these values as close to normal as possible. The total parenteral supportive medication administered was 3000 cc of 5 per cent glucose in saline, 4000 cc of normal saline by dlysis, 74,000 cc of Han nann's solution, 1500 cc of red blood cells suspended in saline, and 4000 cc of Amigen. Amigen was used experimentally because of its protein content but was discontinued due to the untoward side-effects of anorexia, nausea, vomiting, malaise and severe generalized headaches. During the most critical phase of the disease five units of regular insulin were administered three times a day before meals to aid carbohydrate metabolism and support the liver.

SUMMARY

(1) We have presented a case of postoperative duodenal fistula of the lateral type which drained 3000 cc. or more a day, and recovered.

(2) A simple and efficient apparatus is described which will drain wounds and sinuses and collect the secretions in a vacuum bottle.

(3) A jejunostomy is life-saving in that it makes possible the resection of all the upper intestinal damage as well as allowing feeding directly into the intestine below the site of perforation.

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A RARE ABNORMALITY OF THE THE ANTEDUODENAL POSITION OF THE CYSTIC DUCT*

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Case Report—The subject of this report was a tall, well-built, white man (E C) of Italian birth. He was 67 years of age, and had been in excellent health until 10 years previously. At the age of 57 he began to suffer dull pain under the right costal margin, and went from one doctor to another without getting much relief.

In September, 1942, a roentgenologic examination demonstrated a nonfunctioning gallbladder and the probability that there were gallstones present. Operation was recommended but the patient preferred to wait. By May, 1943, the pain had increased in severity. The patient had lost 25 pounds, and had developed a slight jaundice. It seemed probable that a stone had moved down causing a partial obstruction of the common duct. At this time the patient requested surgical treatment.

Operation—May 31, 1943. Under general anesthesia (30 cc of paraldehyde rectally, followed by nitrous oxide and oxygen), the gallbladder was exposed. It was large, thickened and tense, and bile could not be expressed out of it readily, but no stones could be felt, there were several large, soft lymph nodes along the neck of the gallbladder.

The diagnosis of cholecystitis without stones was made, and cholecystectomy was begun at the fundus. Soon after starting the procedure it was noticed that the cystic duct passed *in front* of the duodenum. All the tape-sponges were removed in order to verify this anatomic abnormality. A cholecystectomy was then completed by freeing the fundus and the neck of the gallbladder in front of the duodenum, where the cystic duct was ligated at a point anterior and inferior to the duodenum at the junction of its first and second parts. By going through the hepatoduodenal omentum the hepatic duct was exposed, it was soft and not distended, but seemed to be somewhat displaced medially. Through the foramen of Winslow, one could feel the common duct, which was soft and contained no stones. While we were considering whether to mobilize the duodenum laterally or follow the stump of the cystic duct in front, in order to expose the common duct, a round, firm mass, the size of a hazel nut, was felt bulging from below into the first part of the duodenum, about one-half inch from the pylorus.

It was thought this might be an adenoma of an aberrant lobe of the pancreas which might have caused pressure on the common duct (especially if such a duct was displaced medially) and that this anomaly might account for the jaundice. It was decided to remove the tumor by the transduodenal route. A transverse incision was made across the first part of the duodenum about half an inch from the pylorus and the tumor was shelled out easily. A probe introduced into the bed of the tumor did not enter the stomach or the duodenum, showing that the mucosa was intact. When it was pushed to the right, however, a gush of thin, clear yellow bile came from under the second portion of the duodenum, indicating that the common duct was patent.

The incision in the wall of the duodenum was sutured with two rows of chromic catgut and a cigarette drain was left against the stump of the cystic duct, and the abdomen closed.

Postoperative Course—The patient had a stormy convalescence at first. For 12 days the major part of the bile drained, probably from the duodenal suture, through the

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ABNORMALITY OF B'LE DUCTS

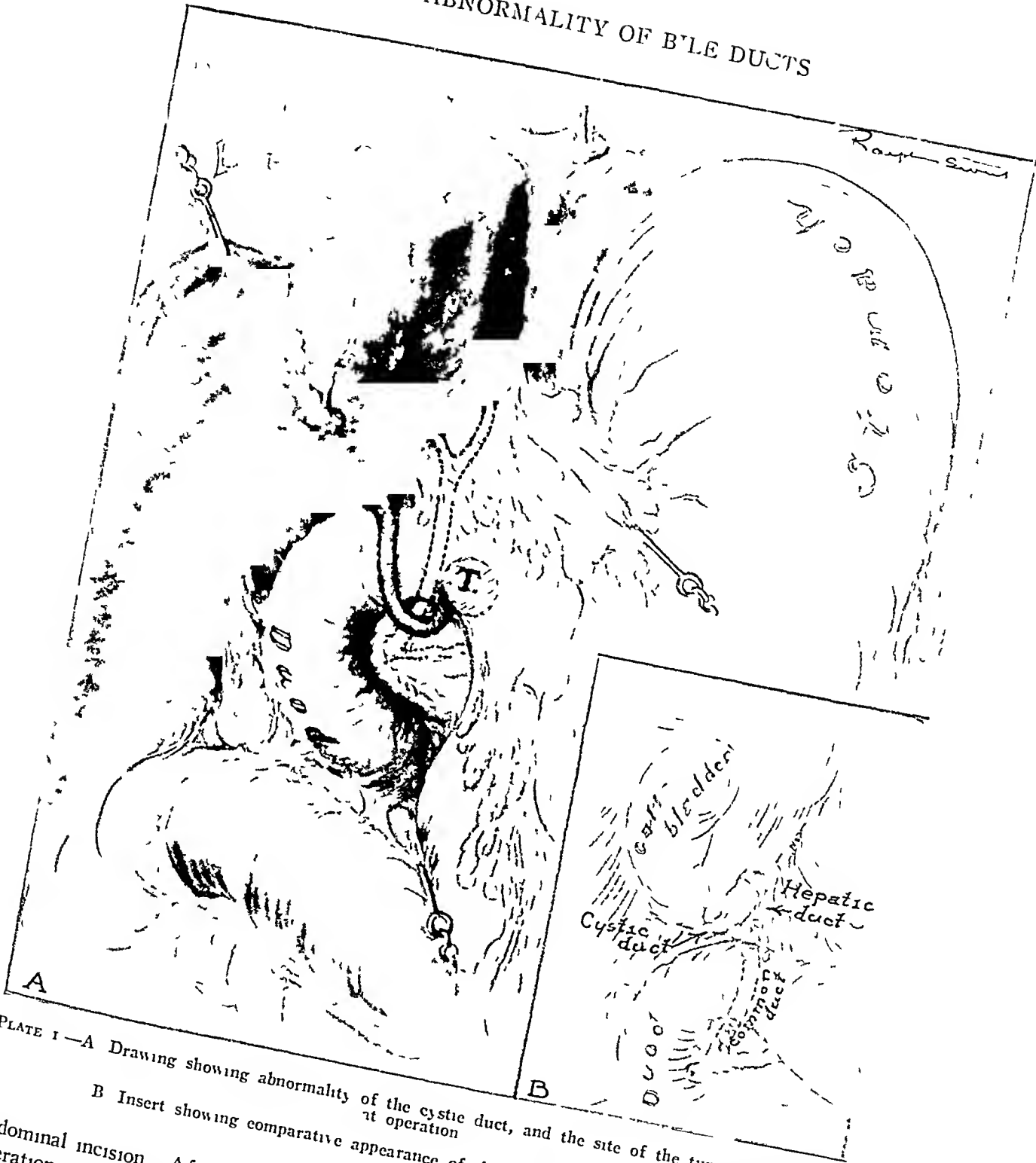


PLATE I—A Drawing showing abnormality of the cystic duct, and the site of the tumor as observed at operation
B Insert showing comparative appearance of the normal anatomic relations

abdominal incision After that the flow of bile decreased rapidly, and three weeks after operation, the abdominal incision was well healed, the biliary fistula having closed entirely The patient had no more jaundice, his appetite was good, and his weight was 167 pounds

Pathologic Report Typical duct carcinoma arising from the bile duct The question of more radical intervention was discussed and was explained in detail to the family They decided in favor of a "Whipple operation" This was performed elsewhere The patient succumbed to shock on the third day The surgeon in the case told me that he found "shreds" of cancer in the head of the pancreas Autopsy was refused

paid especial attention to anomalies of the biliary ducts at . . . (1913), and Gross² (1936)

Kehr sketched every possible abnormality of the bile ducts, but he made no mention of any instance of an anteduodenal position of the cystic duct. Gross's comprehensive report, containing 148 cases of anomalies of the gallbladder, collected from the literature, failed, also, to mention an anteduodenal displacement of the cystic duct.

Embryology can probably throw some light on this unusual anomaly. From the text books dealing with the development of the abdominal organs we learn that the liver "bud" starts from a ventral diverticulum appearing on the foregut (duodenum) in the first weeks of intra-uterine life. The distal part of that bud forms the liver, while the proximal part of the original diverticulum constitutes the bile ducts of which the gallbladder is just an evagination.

In normal subjects, when the gallbladder "bud" appears, a certain time after the formation of the liver bud, the cystic duct joins the common duct at two-thirds or three-fourths of the distance from the surface of the liver to the duodenum and always passes *behind* this portion of the intestine. Should the gallbladder "bud" appear very early after the liver bud has formed, the gallbladder will be found very near the liver, or it may even be "completely intrahepatic," a condition of which Gross found four instances mentioned in the literature.

Failure of the gallbladder "bud" to appear altogether results in total absence of the gallbladder. Gross listed 38 such occurrences from the literature.

The case herewith reported would lie between those two extremes, the gallbladder bud probably started to grow late and at the time when the rotation of the stomach and duodenum to the right had been completed and these viscera had already become firmly attached to the vertebral column, by this disposition, the gallbladder bud, appearing too late, would be prevented from expanding behind the duodenum but would be deflected forward and forced to assume an anteduodenal position.

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TREATMENT OF HORSESHOE KIDNEYS

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REINEMENTS in operative technics have resulted in increasing interest in congenital anomalies of the genito-urinary tract. During recent years a voluminous literature has accumulated concerning the various types of renal fusion, especially the so-called "horseshoe kidney." Morgan presented the first accurate description of this anomaly in 1820, although it was mentioned by Berengari da Carpi as early as 1522. In 1934, Gutiérrez correlated the many features of horseshoe kidney in his monograph and established it as a distinct clinical entity capable of producing bizarre symptom complexes.

The purposes of this report are (1) To remind practitioners of the incidence and significance of horseshoe kidneys, (2) to review the accepted forms of surgical treatment, and (3) to add a case to the very small group which has been treated successfully by symphysiotomy and bilateral nephropexy.

When the renal blastemata or anlagen fuse along their mesial borders instead of remaining separate, the resultant anomaly is classified as one of median fusion. The horseshoe kidney represents the most common type of such anomalies and has been observed in embryos 30 Mm long. In 90 per cent of the cases this fusion occurs at the lower poles while in the remaining 10 per cent the upper poles are joined. The isthmus may be merely a thin fibrous cord, a tenuous membrane, or a thick mass of renal tissue containing glomeruli and tubules. This isthmus usually passes anterior to the aorta and vena cava. Four cases have been reported in which the isthmus was dorsal to the great vessels and in one reported instance the isthmus passed *between* the aorta and vena cava. According to Eisendrath and Rolnick, the most common level for the isthmus is at or close to the aortic bifurcation.

Variations in the origin, number and size of the renal vessels are encountered frequently. The isthmus may have what appears to be a separate blood supply. The sympathetic nerve plexuses and the ureters usually cross the anterior surface but specimens have been reported in which the ureters were dorsal to the isthmus.

Normal rotation of the kidneys is prevented by the fusion and the resulting displacement of the pelves forms the basis for pyelographic diagnosis. In some instances the soft tissue shadows of the kidney demonstrate the horseshoe shape of the parenchyma. Occasionally the isthmus may be outlined distinctly in plain roentgenograms. Some examiners have been able to palpate thick zones of fusion in thin patients. The diagnosis of horseshoe kidney usually is made by the pyelographic evidence of inversion and rotation of the renal

pelves, unusual localization of the elongated and bizarrely-shaped pelvis and peculiar position of the ureters

Foley has summarized the roentgenologic findings typical of horseshoe kidney as (1) Low position of the kidneys, (2) inferior calices extending dorsally or medially from the pelvis, (3) ureteropelvic junction on the ventral surface instead of at the medial border of the pelvis, (4) ureter overlying the pelvis and crossing the abnormally directed inferior calices, and (5) long axis of the kidney oblique toward the midline below

Horseshoe kidneys have been classified in a variety of ways but these groupings embody the following distinctions

- I No renal pathology except the fusion and no symptoms
- II Pathologic conditions superimposed on the anomaly, with or without symptoms
- III No secondary renal pathology but definite symptoms referable to the fusion *per se*

I HORSESHOE KIDNEY ALONE, WITHOUT SYMPTOMS

The anomalies of this group are discovered incidental to some other clinical study or are noted during postmortem examinations. The autopsy incidence of horseshoe kidney indicates that this is by far the largest group of such cases. Statistics vary from the 1 385 reported by Shoemaker and Braasch to the ratio of 1 1000 noted by Davidsohn, as shown in Table I

TABLE I

INCIDENCE OF HORSESHOE KIDNEY DISCOVERED AT AUTOPSY

Authors	Ratio
Shoemaker and Braasch	1 385
Papin	1 500
Lipschutz and Hoffman	1 576
Naumann	1 600
Lowsley and Kirwin	1 600
Jeck	1 643
Thompson	1 678
Motzfield	1 710
Boetz	1 715
Carlier and Girard	1 862
Davidsohn	1 1000

From these statistics it is obvious that most horseshoe kidneys are not recognized clinically. Although many of these patients undoubtedly have no symptoms to direct attention to the anomaly, some patients may belong in Group III because of vague abdominal complaints which are not diagnosed properly or for which the patient does not seek relief.

Urologists are agreed that patients with asymptomatic horseshoe kidneys and no secondary renal pathology should not be subjected to operation because of the anomaly alone. There can be no question that the lives of patients in this group are not jeopardized by further observation.

II SECONDARY RENAL PATHOLOGY WITH OR WITHOUT SYMPTOMS

From the many case reports in the literature it is apparent that this group represents the next most common type of horseshoe kidney. Many writers insist that secondary pathologic processes tend to develop more frequently in anomalous kidneys than in normally formed organs. Recent evidence by some investigators adds support to this contention even though the subject remains controversial.

Almost every known type of pathology has been found in horseshoe kidneys. DeVries reported a case in which one-half contained a calculus, a papilloma and a hypernephroma. Joly claims that calculi occur six times more frequently in horseshoe kidneys than in normal ones. Walters and Priestley reported 68 cases of horseshoe kidney, verified at operation, and only seven had no secondary pathology. Rathbun reviewed 108 cases and reported calculi in 32, hydronephrosis in 18, tuberculosis in 12, and pyonephrosis in 11.

The symptoms in such cases are those characteristic of the secondary diseases in most instances. Occasionally these complaints are combined with those typical of the "horseshoe kidney syndrome" which will be considered in the next group. Not infrequently, however, the secondary pathology in horseshoe kidneys is discovered accidentally in the course of routine examinations just as such conditions some times are found in normally formed kidneys. These asymptomatic patients may require radical therapy because of the gravity of the secondary pathology (*e g*, hypernephroma, without clinical symptoms).

Braun has been credited with the first attempt to remove the diseased half of a horseshoe kidney in 1882, without success. Six years later Socin removed the hydronephrotic half in two stages, and the patient lived. Since then there have been many case reports of partial removal of horseshoe kidneys and other types of surgery performed because of secondary pathology. In 1928, Lowsley and Kirwin collected 92 cases of heminephrectomy. Eisen-drath and Rolnick mention 250 operated cases and list the following procedures, Primary heminephrectomy, 117, pyelotomy and nephrotomy, 70, secondary heminephrectomy, 13, combined pyelotomy, symphysiotomy and nephropexy, 17, pyeloplasties or ureterolyses, 3, various procedures employed in injuries to horseshoe kidneys, 9.

Goldstein and Abeshouse (1943) reported four cases in which the operative procedures were limited to heminephrectomy and pyelolithotomy. From their study they concluded that "horseshoe kidneys that are exposed because of renal disease should have hemisection after the pathologic process has been corrected, horseshoe kidneys with small calculi in the calices should be heminephrectomized, horseshoe kidneys causing pain or other symptoms without renal disease should be sectioned."

It is generally agreed that pathology in either half of a horseshoe kidney should be treated the same as similar lesions in nonfused kidneys. If removal

of the disease and part is indicated, heminephrectomy is the procedure of choice. If less extensive division seems necessary (*e g*, pyelolithotomy), the isthmus of the kidney is divided and nephropexy performed for reasons to be explained in the following group. The consensus of opinion is that extraperitoneal approach through the usual lumbar incision should be employed for all such operations.

III NO SECONDARY PATHOLOGY, BUT VAGUE SYMPTOMS

Horseshoe kidneys without additional pathologic changes are now recognized as being capable of producing symptoms which can be cured only by operation. Gutiérrez maintains that continuous pressure exerted upon the pre-isthmal nerve fibers by the abdominal viscera and upon the underlying mesenteric plexus and lumbar sympathetic nerves by the isthmus is the chief factor in producing the abdominal pain of the horseshoe kidney syndrome.

Rovsing has been credited with first describing the syndrome encountered in this group. This is characterized chiefly by pain in the upper abdomen, produced or aggravated by ventral extension of the spine. It may vary greatly in intensity and at times may simulate the crises noted in *tabes dorsalis* but usually is dull and relatively mild.

Gutiérrez has outlined the horseshoe kidney syndrome as (1) urologic symptoms, (2) indefinite renal or abdominal pain, and (3) reflex symptoms manifested by gastro-intestinal disorders.

Foley claims that the pain present in his series of seven patients was fairly typical of renal origin.

Lowsley and Knapp explain that 12 patients observed at the New York Hospital with horseshoe kidneys had been operated upon for relief of symptoms which had been diagnosed erroneously as chronic appendicitis, cholecystitis, cholelithiasis and other intra-abdominal conditions which were not connected with the genito-urinary tract.

Martinow performed the first symphysiotomy for horseshoe kidney in 1910, and used a transperitoneal approach. Papin, in 1922, performed the first successful division of the isthmus through an extraperitoneal exposure. Donohue, in 1932, reported the first such extraperitoneal operation in this country.

Baker and Colston found only 24 cases treated by symphysiotomy in the literature prior to 1936. Seventeen of these were from Europe. They added two of their own cases to this group.

Stride was unable to find any additional cases treated by symphysiotomy in the literature from 1936 to 1939 but reported his case in which symphysiotomy and nephropexy were performed, followed one year later by nephropexy on the opposite side.

In 1940, Foley collected only 19 authentic cases of symphysiotomy and nephropexy from the accumulated literature and added seven such cases which had been under his observation. This group included the case

reported previously by Donohue, one unilateral fused kidney and five new cases of horseshoe kidney. Because of pain which persisted after the unilateral nephropexy, Foley found it necessary to perform nephropexy on the opposite side in four of his patients. In all four instances, fixation of both halves resulted in disappearance of all symptoms. Of the total 26 patients in the literature who had been treated by symphysiotomy and nephropexy and reviewed by Foley, 92 per cent had excellent or good results and only one operative death resulted.

Goldstein and Abeshouse suggest that "cases without definite renal pathologic changes but presenting symptoms either of renal or other origin should certainly receive the benefit of surgery by performing symphysiotomy and nephropexy. We are certain that failures are going to be reported. In view of the fact that something must be done about these cases they should be given the benefit of the doubt."

In light of these observations it seems reasonable to conclude that any uncomplicated horseshoe kidney with this symptom complex should be subjected to symphysiotomy and nephropexy in the absence of other explanatory pathology and nephropexy should be performed on the opposite side if these symptoms persist.

The extraperitoneal lumbar approach is recognized as the exposure of choice for this group.

Because of (1) the interesting and confusing symptomatology, (2) the extreme paucity of symphysiotomy reports in the literature, (3) the need of bilateral nephropexy in this instance, (4) the successful nonoperative treatment of postoperative calculi, and (5) the excellent end-result, the following case is added to the very small list of such patients who have been treated by these methods. This represents the only horseshoe kidney found at this hospital in 747 patients studied pyelographically during the 12 months from September 1, 1942, to August 31, 1943.

CASE REPORT

The patient, a 28-year-old white male, was admitted on the Medical Service, November 3, 1942, complaining of upper abdominal and left flank pain. For two years he had had frequent, dull, nonradiating, epigastric pain aggravated by lying flat on his back. This was unrelated to meals. There had been no nausea, vomiting or urinary symptoms. At no time was the discomfort severe enough to alter his general activity and relief was obtained usually by erect position. On the day of admission he began to have dull, nonradiating pain in the left flank for the first time.

Physical examination was negative except for slight tenderness just above the umbilicus and in the left costovertebral angle. There were no palpable masses. Blood pressure 118/70.

The urine showed specific gravity 1.025, no albumen or sugar, occasional WBC per HPF, and was sterile on culture. Blood studies revealed RBC 4,670,000, Hb 90 per cent, WBC 9100, sedimentation rate 2 Mm in one hour, negative Kahn, clotting time 5 minutes, bleeding time 4 minutes, NPN 30.2 mg per cent.

Roentgenograms of the esophagus and stomach were normal but the duodenal bulb showed some irritation. This subsided on antispasmodics, but the original complaints

FIG 1



FIG 2



FIG 3



FIG 4

persisted unchanged. Subsequent plain films of the abdomen showed two opacities in the region of the left kidney (Fig 1). An intravenous urogram showed these to be included in the left renal pelvis, normal function on both sides, incomplete rotation of both pelves, the right ureter deflected to the left and the right pelvis almost in the midline (Fig 2). Cystoscopy revealed a normal lower urinary tract and retrograde pyelograms presented essentially the same renal picture as noted on excretion urography. The kidney shadows were seen to extend towards the midline with the lower poles apparently continuous.

A diagnosis was made of horseshoe kidney with calculi in the left half. The patient was transferred to urology and, on November 17, 1942, the left half of the kidney was explored, under nitrous oxide-ether anesthesia, through a flank incision.

The left half of the kidney was elongated, the pelvis and ureter were on the anterior surface and at the lower pole was an isthmus of fusion 3 cm wide and 1.5 cm thick. Within the pelvis could be felt the larger of the calculi. The isthmus was divided between two rows of No. 1 chromic catgut mattress sutures, after which the kidney was delivered easily, the pelvis opened, the calculi removed, and the pyelotomy wound closed with continuous No. 0000 chromic catgut, without drainage. The posterior surface of the kidney was sutured to the deep lumbar muscles with No. 1 chromic catgut after rotating the lower pole laterally to assume a more normal position. The renal fossa was drained and the incision was closed in layers with No. 1 chromic catgut in the muscles and fascia and silk in the skin.

The convalescence was entirely uneventful. The incision healed promptly. The left flank pain disappeared entirely but the epigastric discomfort persisted, although the latter was not severe. Postoperative roentgenograms showed no remaining calculi, the left kidney in much better position, with no suggestion of hydronephrosis and the right kidney still occupying the position over the great vessels (Fig 3).

The patient was discharged December 24, 1942. He continued to have the epigastric discomfort at irregular intervals and was readmitted March 20, 1943. Examination showed no tenderness or weakness on the left side, localized tenderness near the midline just above the umbilicus and was otherwise negative. All laboratory studies, again, were negative and the urine had remained sterile. Further roentgenologic studies showed no appreciable change from the last examination (Fig 3). The persistent complaints were thought to be due entirely to the abnormal position of the right kidney.

On March 25, 1943, the right kidney was exposed extraperitoneally through a flank incision under nitrous oxide-ether anesthesia. This half of the original horseshoe kidney also was elongated. The ureter was grossly normal and joined the pelvis on the anterior surface of the kidney with no demonstrable obstruction. After freeing the upper portion of the kidney, the isthmus was exposed, freed easily from the vena cava but was found to be adherent at the site of the previous division overlying the aorta. A large artery and vein supplied the isthmus in the midportion and after ligating and dividing these vessels, the tissue of the isthmus promptly changed color. Further division of the isthmus near the preaortic adhesions resulted in no bleeding and permitted free delivery of the kidney.

The discoloration of the isthmus extended to the lower pole of the kidney. This

FIG 1—Plain roentgenogram showing two calculi in region of left renal pelvis
(Photograph by Signal Corps, U. S. Army)

FIG 2—Preoperative intravenous urogram showing good function, incomplete rotation kidneys near midline (especially right), and soft tissue shadow of right kidney extending to vertebrae inferiorly
(Photograph by Signal Corps, U. S. Army)

FIG 3—Intravenous urogram after symphysiotomy, left pyelolithotomy and left nephropexy showing left kidney in more normal position, no hydronephrosis and right kidney still near midline
(Photograph by Signal Corps, U. S. Army)

FIG 4—Retrograde pyelograms after right nephropexy showing both kidneys and ureters in relatively normal position without hydronephrosis
(Photograph by Signal Corps, U. S. Army)

wedge of tissue was excised and the pole of the cortex was closed with No 1 chromic catgut over fat. The kidney was stated into the space just below the diaphragm and fixed with three No 1 chromic catgut sutures which had been placed beneath the true capsule on the posterior surface and brought out through the full-thickness of the lumbar muscles. One Penrose drain was left in the wound and the incision was closed in layers.

The wound remained dry and the Penrose drain was removed after 48 hours. The

FIG 5

FIG 6



FIG 5—Plain roentgenogram five weeks after second operation showing new calculi in both renal areas and in lower segment of left ureter
(Photograph by Signal Corps, U S Army)

FIG 6—Plain roentgenogram after repeated lavage with Suby's solution "G" showing disappearance of shadows noted in Figure 5
(Photograph by Signal Corps, U S Army)

incision healed *per primam*. The epigastric pain disappeared entirely. A plain roentgenogram and pyelographic studies on the twentieth postoperative day showed no calculi, no change in the left kidney and the right kidney in much better position with no hydronephrosis (Fig 4). The patient was ready to leave the hospital when, suddenly, on April 26, 1943 (32 days postoperative) he began to have sharp pain in the left flank radiating to the left side of the scrotum. Further roentgenograms showed calcification in both renal areas and in the left ureter (Fig 5). From the available cystoscopic and radiographic evidence it was assumed that these calculi had developed rapidly and probably were comparatively soft. Blood calcium and phosphorus determinations were within normal limits.

During the following three weeks the patient was cystoscoped, indwelling bilateral ureteral catheters were inserted for 48 to 72 hours on six occasions, and the renal pelvises were lavaged with Suby's solution "G" (citric acid 32.3 Gm, magnesium oxide 3.8 Gm,

sodium carbonate 4.4 Gm, distilled water 2,000 cc) at intervals of one to three hours. Small doses of sulfathiazole were given during this period of frequent instrumentation. The ureteral calculi passed spontaneously. The calcification in both renal pelvises disappeared (Fig 6). The patient remained asymptomatic and left the hospital, June 1, 1943, with sterile urine.

Follow-up studies have been frequent and have failed to show any recurrence of the calculi. The patient has remained asymptomatic. Pyelographic study, September 21, 1943, failed to show any change from that demonstrated after the second operation (Fig 4). The patient was seen last September 21, 1943, but correspondence of December 15, 1943, reveals that he is still entirely asymptomatic.

Résumé This patient with a horseshoe kidney had epigastric symptoms more or less typical of the classical syndrome and was treated for pyloric spasm (which had been demonstrated roentgenologically) without success. Relief was obtained only after symphysiotomy and bilateral nephropexy. Despite the chronicity of the symptoms due to the anomaly *per se*, he did not seek treatment until calculi had formed in the left half of the kidney and had become symptomatic. If these calculi had not been demonstrated in a routine plain roentgenogram, attention might never have been directed to the urinary tract and the fundamental pathology might have gone unrecognized. Although removal of the calculi and fixation of that kidney promptly eliminated the left renal complaints, the more classical symptoms persisted because the right kidney was situated over the great vessels. These in turn stopped as soon as the deformity was corrected. Even though this patient had no postoperative hydronephrosis and the urine remained sterile, calculi developed in both kidneys after the operation on the right. These were dissolved or passed spontaneously as fragments after frequent irrigation with Suby's solution "G" through indwelling ureteral catheters. The fact that the recurrent calcification was recognized early may have enhanced the response to this nonoperative treatment of the stones. The patient has remained asymptomatic and has had no further recurrences during the subsequent seven months.

SUMMARY

The incidence of horseshoe kidney is approximately 1/600 in clinical and postmortem examinations. Most of these are discovered accidentally, have no secondary renal pathology, produce no symptoms and require no treatment.

Not infrequently, secondary lesions develop in horseshoe kidneys and may be of any of the pathologic types which affect the nonfused kidney. These cases represent the most common type of symptomatic horseshoe kidneys which are recognized clinically and the symptoms usually are due to the secondary pathologic processes. Secondary disease of major significance should be treated by heminephrectomy. Less radical procedures which preserve both halves of the kidney (*e g*, pyelolithotomy) should be accom-

panied by symphysiotomy and nephropexy on that side because of the danger of remaining symptoms attributable to the fusion alone

A small but distinct group of horseshoe kidneys without secondary pathology will present vague abdominal or back symptoms which may be mistaken for gastro-intestinal disorders or pathology in some other system. Apparently the symptoms of the "horseshoe kidney syndrome" are produced by pressure on adjoining nerves by the isthmus of fusion or by the ectopic renal masses. Relief is obtained by symphysiotomy and nephropexy. In a few such cases it may be necessary to perform a nephropexy on the opposite side also before *complete* relief is obtained.

In all surgery on horseshoe kidneys the conventional, extraperitoneal, lumbar approach is satisfactory and the one of choice.

Another case is added to the small list of patients treated successfully by symphysiotomy and bilateral nephropexy. Pyelolithotomy also was performed in this case. Recurrent calculi were recognized early and dissolved with Suby's solution "G" after irrigating the renal pelves through indwelling ureteral catheters. The patient has been followed for seven months with no further recurrence of calculi or symptoms.

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WILMS' TUMOR IN A HORSESHOE KIDNEY*

CASE REPORT

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THIS CASE is presented because it combines an unusual lesion with several problems in clinical management

CASE REPORT

The patient, a child, age six, was admitted to the University of Pennsylvania Hospital in November, 1943, with a large abdominal tumor and high fever. She had apparently been well until the age of two and a half years, when she had the first of a long series of unexplained febrile illnesses usually ascribed to upper respiratory infections and bronchitis. During one of these episodes she was studied in another institution and found to have what was thought to be an enlarged spleen. No definite diagnosis was made and the child disappeared from medical observation until shortly before the present hospitalization. On admission, she appeared acutely ill with a high, spiking temperature ranging between 101° and 104° F. A large, smooth, rounded mass occupied almost the entire left side of her abdomen. Tympany over the mass suggested that it was retroperitoneal and not of splenic origin. Blood pressure 140/94. Blood urea nitrogen—normal. Repeated urinalyses were normal. Blood studies showed normal values except for a mild leukocytosis.

An intravenous urogram showed a horseshoe kidney in an ectopic position with the right component overlying the sacrum and the left lying just above the pelvic brim. There was good clearance of dye bilaterally.

A large soft tissue mass containing calcium was situated in the left upper quadrant above the renal area. The iliopectas shadow on the left was obliterated in addition to the transverse process of the 12th dorsal vertebra.

Barium enema showed an intrinsically normal colon displaced forward by the mass. Chest roentgenograms and complete bone survey were negative.

Operation—The child was operated upon November 19, 1943, through a transperitoneal approach and a tumor found arising from the upper pole of the left segment of a horseshoe kidney. The lesion, including the entire left renal component, was removed without difficulty, dividing the horseshoe at its symphysis. There was no evidence of any metastatic spread. The tumor was apparently completely removed. The child's postoperative convalescence was entirely uneventful. Her fever disappeared and she was discharged two weeks later with a normal urine, blood urea nitrogen and urinary output. Since discharge she has remained well, gaining almost 15 pounds in two months.

Pathologic Examination—The microscopic sections showed the lesion to be an embryoma of the kidney containing both carcinomatous and sarcomatous elements. There was no evidence of infiltration in the small margin of normal kidney removed with the tumor. *Gross Description* The specimen consists of a rounded encapsulated mass 15 x 10 x 48 cm and a small piece of tissue apparently kidney measuring 5 x 3 x 2 cm. The large mass is grey and shows some nodularity and on cut surface it bulges. It is quite soft. When cut, the surface is not homogeneous but apparently composed of several elements. The greater part is a yellow-grey, very soft lobular tissue in the center of which are strands of yellow and yellow-green tissue. This is slightly more firm. At one

* Presented before the joint meeting of the New York Surgical Society and the Philadelphia Academy of Surgery at Philadelphia, February 9, 1944.

pole there is a small hemorrhagic cystic area about 2 cm in diameter. Sections are taken from several areas of the tumor. The small specimen shows on one side apparently normal pink tissue from kidney and on the other side greyish tissue but fairly firm. Sections are taken across this at three points and parallel to the grey surface. These are labelled A. Calcified plaques are palpable beneath the capsule. Fixation—Bouin's. *Microscopically*, the specimen shows large areas of low columnar cells which have quite large nuclei. These are arranged in a glandular fashion in some places but in many other areas they seem to be wildly growing with no tendency toward acini formation. Some acini shows a tendency toward cyst formation. There are many necrotic areas in the tumor and some areas of hemorrhage. There are some fibrous tissue septa through the tumor, some of which have a myxomatous appearance. The small piece of kidney shows no evidence of infiltration of tumor in any area. No smooth muscle elements are found. *Pathologic Diagnosis* Embryonal sarcoma of kidney (adenosarcoma type). *Note* This tumor apparently belongs with adenosarcoma sub-classification of the Wilms' tumor group although the glandular differentiation predominates. The resection is wide of the tumor.

DISCUSSION

The problems presented by this case are First, the best treatment of a Wilms' tumor, and second, the problem of treating a Wilms' tumor in one segment of a horseshoe kidney. Although embryomas of the kidney are one of the most common tumors of the abdomen in childhood, rarely have these children lived to reach puberty. It has been stated that in a series of 500 tumors of all types in children, 20 per cent were kidney tumors. Practically all of these were embryomas. Considerable pessimism has sprung up regarding the prognosis for children with this tumor, and while it is still true that the toll is high, the outlook is not as hopeless as many would suggest. A review of Ladd's statistics for the Children's Hospital in Boston indicates that about 25 per cent of his cases have survived long enough to be considered cured.

In the treatment of these tumors there are two schools of thought. The first, and older group, advocates preoperative irradiation over the growth with two objects in mind: (1) To reduce the size of the local mass so that it will be technically easier to remove, and (2) to kill off the more malignant, radiosensitive cells in the tumor and thus prevent their escape into the blood stream during the operative manipulation.

Again, Ladd, with probably the greatest personal experience with the problem at the present time, recommends removal of the mass as soon as discovered using the transperitoneal approach with ligation of the renal vessels before manipulation of the mass. He is convinced that roentgenotherapy has been too widely employed without consideration of the end-results obtained. Perhaps the most convincing arguments in favor of his thesis are the reputed cures. The few apparently cured patients referred to in the literature received no preoperative irradiation.

During the last eight years Ladd has removed 22 Wilms' tumors, with no operative mortality, thus refuting the statement that preoperative irradiation is necessary to obtain a low operative mortality.

Listed in his series as probable cures of renal embryomas are 14 out of

56 cases alive and well from two to 21 years after operation. Only one of those 14 patients had preoperative radiation.

Bothe, in an analysis of 44 cases from the literature, found that recurrences and metastases were reported in some cases ten years after the removal of the primary growth. With this possibility in mind he states that the most skeptical analyst would accept but eight of the 44 as cured. It is important to note that the eight cases of probable cures never had either pre- or postoperative irradiation. He personally adds seven cases treated without irradiation, and finally states that he agrees with Ladd in voicing the opinion that in these mixed tumors or embryomata immediate removal gives a better chance of cure than does irradiation and a delayed nephrectomy.

Finally, the case of the complicating problem of a horseshoe kidney must be considered. This, in itself, is not a particularly uncommon anomaly. It is associated with a high percentage of pathologic lesions mostly dependent on the high ventral implantation of the ureters, a situation resulting in poor drainage from the renal pelvis. There are few recorded instances of renal tumors associated with horseshoe kidneys. Fortunately, this tumor was isolated in the upper pole of one segment and the remaining tissue appeared normal and uninvolved.

Gutiérrez speaks of the "horseshoe kidney disease" stating that these kidneys almost invariably, sooner or later, develop nephritis, pyelitis, pyonephrosis or stone, with resultant death. They are not immune to hypernephroma and papillary carcinoma but rarely produce the Wilms' lesion. In fact, we could not find a single case of the latter reported in the literature.

This anomaly is usually the result of lower pole union, seldom of upper pole union, so often accompanied by other anomalies, such as horseshoe suprarenals, diaphragmatic hernia and spina bifida. Of great importance is the anomalous blood supply of this double kidney. The arteries usually enter the kidney posterior to the pelvis and vary in number from four to as high as six with one or two entering the symphysis itself. The ureters cross in front of the symphysis and anomalous or aberrant arteries are the rule, often taking their origin from the arteries of adjacent structures. These conditions must, of necessity, jeopardize a successful transplantation of the reconstructed nephros.

The question of further care for this child now remains. Roentgenotherapy has been decided against because she has no known malignancy remaining in her body. If she survives a sufficiently long period of time without metastasis it would seem advisable to attempt some form of nephropexy to protect her remaining kidney from the usual obstructive and inflammatory processes resulting from the ectopic position of the organ, its ureter and pelvis.

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CRUDE PENICILLIN: ITS PREPARATION AND CLINICAL USE EXTERNALLY

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THE MANY REPORTS on the parenteral use of concentrated and purified penicillin have established its efficacy in cases of bacteremia, meningitis and internal abscesses. Florey,¹ Abraham, Chain and Fletcher,² and the Committee of Medical Research,³ have also reported that the concentrated and purified penicillin has been effective when applied externally in cases of acute osteomyelitis, furuncles, soft tissue abscesses and wounds. Recently, Robinson and Wallace⁴ investigated the possibility of using crude penicillin externally, as the supply of the purified product is still limited and not generally available. Filtrates of *Penicillium notatum* cultures and gauze dressings which were inoculated with the fungus were applied directly on infected wounds and abscesses. Excellent results were obtained when this treatment was continued for three to six days.

As crude penicillin seemed to be a promising therapeutic agent for localized infections, a study was undertaken at the Willard Parker Hospital to determine the efficacy of this product when applied as nose and throat drops in cases of laryngotracheal infections. Crude penicillin was available at this hospital, as it has been used since 1941 in media to isolate *H influenzae* from mixed cultures.⁵

PREPARATION OF CRUDE FILTRATES OF PENICILLIN

The crude penicillin filtrates used were prepared by the Fleming⁶ method, with a few modifications. We found that the following medium gave excellent yields of penicillin.

Tryptose-phosphate broth—Difco	29.5 grams
Magnesium sulphate	1.0 gram
Potassium chloride	1.0 gram
Sodium nitrate	3.0 grams
Brown sugar	30.0 grams
Tap water	2.000 Ml

Sterilize in autoclave for 15 minutes at 15 lbs

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PROCEDURE

1 A fairly large inoculum of both spores and mat of a known culture of *Penicillium notatum*, obtained from the American type culture collection, was grown in shallow layers of broth. Seventy-five milliliters of this broth in 250 Ml Erlenmeyer flasks gave the best yields of penicillin.

2 The cultures were kept at room temperature (20° C) in the dark for eight to ten days, depending on the rate of growth. A heavy mat, with many spores, and alkalinity was used as evidence of penicillin production.

3 *Potency Tests* The broth of each flask was then titrated by the turbidimetric method,⁷ since the amount of active principle of these cultures is not always the same. Standard cultures of *Staphylococcus aureus* and *Streptococcus hemolyticus*⁸ were used as the test strains. Purified penicillin* containing 102 Oxford units per mg⁹ was used as a standard to determine the number of units of penicillin in the crude preparation. The test was performed by making serial dilutions of both types of penicillin in 10 Ml of beef heart infusion of broth as follows: 1 50, 1 100, 1 500 and 1 1000 in duplicate. Eighteen-hour broth cultures of both test strains were previously adjusted to contain 1×10^7 micro-organisms per Ml McFarland scale. One-tenth milliliter of this dilution of the staphylococcus was then added to each tube of the first set of dilutions of the two penicillin preparations and the streptococcus to the other set. Failure to develop turbidity after 18 hours incubation at 37° C was accepted as evidence of inhibition. Inhibitory action was determined by the least amount of penicillin necessary to inhibit the growth of the inoculum. It was found that our preparation usually contained approximately 800 units per Ml.

4 After potency tests were read, the broth of those flasks showing at least 500 units per Ml were pooled and the reaction was then adjusted to approximately pH 6.8 with 3 per cent HCl, using phenol red as the indicator.

5 The broth was then filtered through a W 'Berkfeld' filter and the filtrate (penicillin) was then retested for potency and also for sterility.

6 Sterility tests were performed by using the same dilutions of penicillin as for potency tests; these dilutions were inoculated into a duplicate set of tubes containing 10 Ml each of dextrose broth, glucose semisolid broth and in beef heart broth. One set of these tubes was incubated aerobically and the other set was incubated anaerobically at 37° C for 48 hours. If there was no evidence of growth the penicillin was considered sterile and safe for clinical use. This crude penicillin, when stored in the refrigerator, maintained its potency for six to eight weeks.

7 Sensitivity tests on the micro-organism isolated from the patient is also performed by the method described in the first paragraph under "*Potency Tests*". This is especially important, as some of the staphylococci and streptococci are resistant to penicillin.

* Purified penicillin was supplied by Merck & Co

8 The mats of *Penicillium notatum* were saved in the original flasks for a period of one week and gauze dressings inoculated with them as needed

CLINICAL USE

This crude penicillin preparation was used as nose and throat drops and for local application on a tracheotomy wound on a ten-month-old infant (M F). This patient, when admitted to the hospital, was acutely ill and had almost complete stenosis due to subglottic edema and thick green exudate on the cords as revealed by laryngoscopy. Cultures from the nose, throat and larynx revealed *hemolytic Staphylococcus aureus*.

Sulfadiazine and steam treatment were given, but the patient's condition grew worse, and five hours after admission a tracheotomy was performed, with complete relief of symptoms. Two days after tracheotomy the patient again developed severe respiratory distress and a bronchoscopy was performed. Aspiration of a waxy mucus plug gave complete relief of symptoms.

Sulfathiazole was then used because of continued temperature and the crude penicillin was applied as nose and throat drops four times a day. The condition of the patient gradually improved, chemotherapy and penicillin were discontinued after the third day of treatment. The tracheotomy wound, however, became infected with the *Staphylococcus aureus* three days after the operation. Sulfathiazole powder, which had been applied to the wound, was ineffectual, and the edges of the wound were necrotic, with a profuse discharge of thick green pus. When the tracheotomy tube was removed six days postoperatively, attempts to close the wound were unsuccessful. Local application of the crude penicillin, 20 drops every hour on the open wound, was begun after the sulfathiazole powder was discontinued. Within three days the wound showed healthy granulation, with a small amount of thin discharge.

After nine days of penicillin treatment the wound was completely healed, leaving a smooth scar. Roentgenologic examination showed only slight compression of the trachea.

Two other patients were treated with this type of penicillin. They had severe pharyngitis caused by *Staphylococcus aureus*. One, C W, a six-year-old male Negro, was admitted to our diphtheria service with a five-day history of illness. The child had a temperature of 104.8° F and was in a comatose state. Examination revealed a membranous tonsillitis, cervical adenitis and a "bull-neck," suggestive of diphtheria. Bacterial examination of nose, throat and larynx revealed *Staphylococcus aureus* in pure culture. Sulfadiazine was administered for the first 48 hours after admission, but had to be discontinued because of oliguria. The condition of the throat remained unchanged. Crude penicillin was then applied by means of a swab directly on the tonsils and pharynx every three hours for three days and four times a day thereafter for three days. On the third day of treatment there were

only small patches of exudate on the tonsils and pharynx, and at the end of seven days there was complete clinical recovery

The third patient treated with penicillin was a five-and one-half-year-old white male, R. C., who presented the same clinical picture as C. W. He was admitted to our diphtheria service on the fourth day of illness. A cheesy, necrotic, thick membrane was seen in his pharynx and throat. Cervical adenitis was also present but not as marked as in C. W. Sulfadiazine was given for four days. Penicillin was administered on the second day after admission in the same manner as for C. W. The bacteriologic examination revealed *Staphylococcus aureus* in throat and larynx. The temperature, which was 103.6° F on admission, dropped to normal on the third day of treatment. The throat was clinically improved three days after penicillin treatment was begun and was completely normal five days after the beginning of the treatment.

These cases illustrate the use of local application of the crude penicillin, which is prepared in our hospital laboratory. This preparation was extremely efficacious in clearing nose and throat infections as well as a tracheotomy wound infected with *hemolytic Staphylococcus aureus*.

ADDENDUM

Since this paper was submitted a case of surgical scarlet fever was treated successfully with both gauze dressings inoculated with *Penicillium notatum* and crude penicillin filtrates. A critically ill, eight-year-old white female was admitted to the varicella service on the third day of illness, with a temperature of 106° F. She had a history of a streptococcus infection of the left hand 19 days before admission. The varicella lesions on the abdomen were infected and an extensive cellulitis, extending up the sides to the line of the nipple and down to the midthighs, was present. Cultures from the infected lesions showed hemolytic streptococcus. The inoculated gauze dressings were placed over the entire abdomen and were kept moist with the crude penicillin diluted to contain 200 units per Ml. The treatment was continued for ten days. The cellulitis began to subside after the third day of treatment and on the fifth day there was only a small area, 3 x 3 inches, which was indurated. On the tenth day all the lesions were healed and there was very little scarring. During local penicillin applications she was also given sulfadiazine, seven grains every four hours. A younger sister of this patient, admitted to the hospital two weeks previously, had the same type of infected varicella lesions and cellulitis of the abdomen. She received only sulfadiazine. The infection localized in the right inguinal area, necessitating surgical intervention. The wound is still draining, two weeks after the operation.

We wish to express our appreciation to Dr. Vera B. Dolgopel and to Dr. Jerome Kohn for their suggestions which aided in the preparation of this paper.

CRUDE PENICILLIN

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POSTOPERATIVE CHRONIC PROGRESSIVE GANGRENE OF THE ABDOMINAL WALL

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THE PURPOSE of this paper is to report a case of postoperative chronic progressive gangrene of the abdominal wall, to point out its characteristic features and to differentiate it clearly from the chronic undermining ulcer as described by Meleney¹ Meleney² reviewed the literature up to 1933 and though there were a number of cases reported, it was believed that many have been lost in the literature because of inadequate titles In a more recent review of the literature³ less than 90 cases were found

Postoperative gangrene should be differentiated from other chronic gangrenous lesions of the skin, namely gangrenous impetigo fusospirochetal gangrene, and amebic infection, with gangrene² Gangrenous impetigo appears in undernourished individuals of any age-group who are frequently suffering from recurrent attacks of dysentery The lesion may be found any place on the body, although the scalp, face, and abdomen are affected most frequently Small vesicles surrounded by a red zone appear first and, subsequently, the center becomes dark gangrenous, and depressed The lesions gradually increase in size and may coalesce, although one to two centimeters is usually the largest size The disease is contagious Fusospirochetal gangrene is found in human bites Inflammation occurs early and this is soon followed by a foul-smelling exudate The margins of the wound are dark grey-green in color The infection spreads to the adjoining bones and joints burrows to the underlying structures and may produce multiple draining sinuses at a distance Amebic infection of the skin, with gangrene, usually occurs after a period of days or weeks following the spontaneous or operative drainage of a liver abscess The edges of the wound are indurated, raised and dark brown As the necrosis spreads the center of the lesion remains ulcerated and covered with granulation tissue The surface contains a foul-smelling exudate of thick, brownish, blood-tinged pus

CASE REPORT

E G, white, female, age 69, married, was admitted to the University Hospital from another institution, September 3, 1942, with a previous diagnosis of a postoperative wound infection

Past History On July 14, 1942, through a McBurney incision, an appendiceal mass was found Sulfathiazole (7 Gm) was placed about the inflammatory mass and the incision was closed, with one cigarette drain On the fourth postoperative day acute

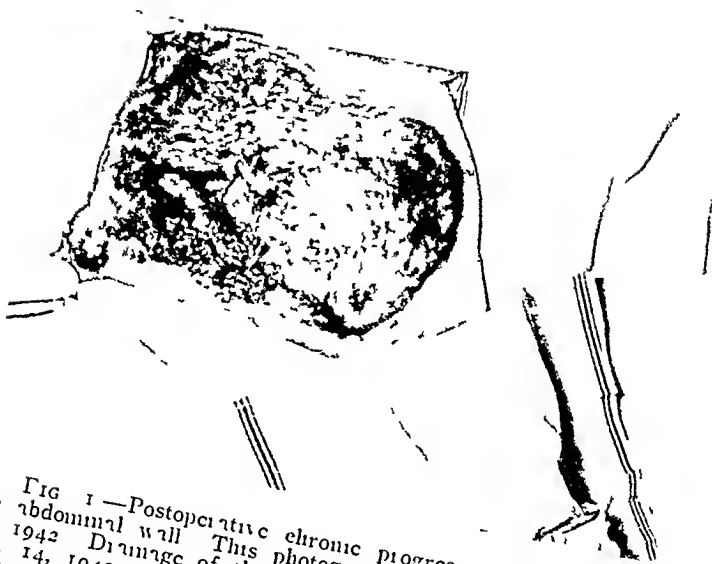


FIG 1—Postoperative chronic progressive gangrene of the abdominal wall. This photograph was taken September 23, 1942. Drainage of the appendiceal mass was performed July 14, 1942. The ulcer extends from the pectoral to the pubic region and laterally to the back. Note (1) area of gangrene (2) area of purplish color, (3) advancing outer zone which is a brilliant red, and (4) the normal zone. The granulation tissue is extensive there is much purulent material. The right rectus muscle is partially destroyed (See Figure 2)

surgical parotitis occurred. This subsided in a few days under roentgenotherapy. On the tenth postoperative day the drain was removed and there was a moderate amount of purulent drainage from the wound. By the 14th postoperative day, the infection had spread to the skin and subcutaneous tissues.

The patient was admitted to the University Hospital on her 51st postoperative day. At this time, the physical examination revealed an elderly, white, emaciated, almost moribund female complaining of severe pain in an ulcerated area around the region of a McBurney incision. The entire abdominal wall was replaced by an ulcer, the base of which was composed of areas of suppuration and granulation tissue, overlaid in some areas with both old and recent blood clots. The rectus muscle was bare in the right lower quadrant. No sinus was found at the wound site leading into the abdominal cavity. The margins of the ulcer were composed of overhanging gangrenous brown skin which, in turn, was surrounded by a purple area about 1.5 cm in width, which was not undermined. This purplish area of skin merged into a red area about 1 cm in width, which shaded off into normal skin (Fig. 1).

Moderate pitting edema of the feet was present. There were no other significant findings. Rectal temperature 99.6° F. Hemoglobin 10 Gm per cent (Sahl). Red blood cells 3,470,000, white cells 14,400. There were no significant findings in the urine. The Wassermann serologic reaction was negative.

Material cultured from various areas of the base and margin of the ulcer revealed *Staphylococcus aureus*, which grew both aerobically and anaerobically, and *B. coli*.

Because the patient was so critically ill, excision of the gangrenous border and adjacent normal skin was delayed. However, the overhanging gangrenous skin edge was debrided and the base of the ulcer irrigated with normal saline solution. Activated zinc peroxide was applied locally only on an empirical basis, with no resulting diminution in the spread of the lesion or change in its characteristics. Blood transfusions were given to replace serum protein loss and to combat anemia. Under this regimen the patient's general condition gradually improved.

On October 26, 1942, the patient's general condition had improved sufficiently to permit administration of a general anesthetic. By this time the base of the ulcer had become relatively clean but the ulcer margin had progressed to the chest wall up to the level of the fourth costal cartilage and around the right flank almost to the midline posteriorly. Material cultured from the ulcer revealed only *Staphylococcus aureus*, which grew both aerobically and anaerobically.

Under nitrous oxide anesthesia, the upper and lateral borders of the ulcer were excised beyond the red zone so as to include normal tissue. Microscopic examination of this tissue revealed nonspecific chronic inflammation and no undermining of viable skin (Fig. 2). About 8 Gm of sulfathiazole crystals were sprinkled over the whole ulcer base, and warm, moist dressings applied. These dressings were changed daily. A blood level of 12 mg per cent was obtained, due to local absorption of the sulfathiazole. A secondary *B. pyocyaneus* infection was controlled by daily irrigations with 2.5 per cent acetic acid.

Under this regimen the border at the site of excision remained stationary and began to epithelize in a few places. Because the base of the ulcer remained infected, skin grafting was not considered at this time.

The patient expired December 5th, 1942 (the 144th postoperative day). Final clinical diagnosis was (1) Postoperative chronic progressive gangrene of the abdominal wall, (2) cachexia, and (3) exhaustion syndrome.

At autopsy the gross pathologic findings consisted of the ulcer involving the whole anterior abdominal wall extending up to the level of the fourth costal cartilage and under the right breast, down over the iliac crests for about 5 cm beyond the inguinal ligaments and posteriorly around the right flank to the midline. The base of the ulcer in the right lower quadrant was formed of thickened peritoneum. No sinus was

round healing from the gangrenous area and general supportive measures and terminal dressing of activated zinc peroxide or sulfonamides were of no

COMMENT—Progressive gangrene should be differentiated from chronic undermining (Meleney) on a clinical basis by the gangrenous distinguish them immediately, and on a bacteriologic basis by isolation. Described the early lesion of *lytic Streptococcus* and *hemolytic Staphylo-*

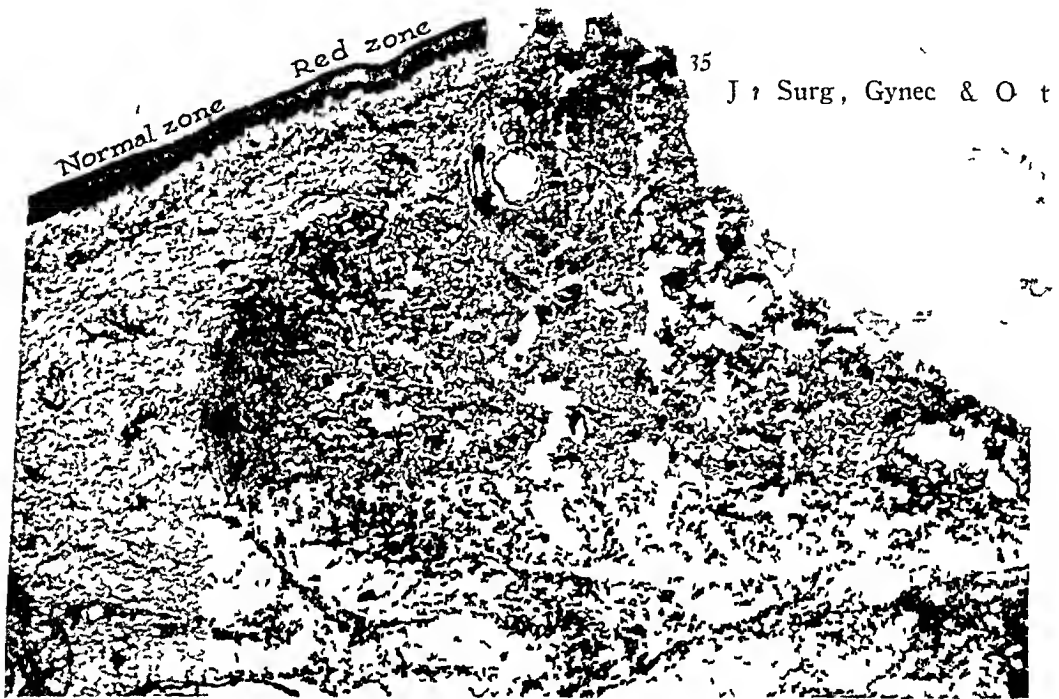


FIG 2—Dr Ruth Balkin Biopsy from margin of ulcer

In the *gangrenous zone* (most of the gangrenous skin previously debrided), the tissue is completely necrotic and only degenerating polymorphonuclear leukocytes and round cells and a few hyalinized connective tissue fibers are seen. The necrosis extends down to the subcutaneous fat tissue. At this point there is a sharp line of demarcation formed by newly proliferated capillaries and small numbers of fibroblasts. This granulation tissue as well as the underlying fat is infiltrated with polymorphonuclear leukocytes and round cells, which diminish in number toward the deeper portions of the fat tissue.

The *purple zone* is characterized by the presence of large numbers of polymorphonuclear leukocytes and a few round cells. There are still a few recognizable collagenous connective tissue fibers in the dermis and the overlying epidermis remains intact. Cultures should be made from the purple zone for the *hemolytic Staphylococcus aureus*.

In the *red zone* there is granulation tissue similar to and continuous with that seen above the fat tissue in the purple and gangrenous zones. Cultures should be made from the underlying tissue in the red zone for *microaerophilic nonhemolytic streptococcus*. Beyond this granulation tissue the capillaries are dilated and there are small infiltrations of cells consisting mostly of the large and small mononuclear cells and a few polymorphonuclear leukocytes. These cellular infiltrations are for the most part perivascular. Note that the purple and red zones are raised above the level of the normal skin ($\times 25$) (See Figure 1).

bacterial gangrene as follows "It usually begins to appear about the end of the first or second week after operation, either as an infection of the whole wound or as a localized induration about retention sutures. At first the wound becomes red, swollen, and tender. Within the next few days the wound margins or the stitch holes develop a carbunculoid indurated appearance. The center of activity becomes purplish in color, while the outer zone takes on a brilliant red tint. The whole region becomes exquisitely

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Spread of Ulcer
Systemic Reaction
Local Reaction
Local Treatment

Prognosis

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Progressive Gangrene
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Microaerophilic non-hemolytic *Streptococcus*
(2) *Hemolytic Staphylococcus aureus*
Zone 1—Gangrenous overhanging margin
Zone 2—Purple area becoming gangrenous (not
undermined) where *hemolytic Staphylococcus*
aureus may be found
Zone 3—Red inflammatory area (advancing
zone where *microaerophilic nonhemolytic*
Streptococcus is most frequently found)
Zone 4—Normal tissue
More rapid
Slight
Excruciating pain
Immediate excision beyond red zone including
normal zone
Sulfonamides locally (?)
Skin graft
Good, if active treatment is undertaken early

Chronic Undermining Ulcer (Meleney)

Any age-group
Usually after incision and drainage
of superficial suppurative processes
Any part of body

Microaerophilic hemolytic Strepto-
coccus

Undermined skin margin which
frequently may be inverted

No gangrene

Sinuses and daughter ulcers may
be present

Less rapid
Variable
Slight pain

Activated zinc peroxide and ex-
cision of undermined margin, if
necessary, skin graft

Good if active treatment is under-
taken early

In debilitated elderly individuals in whom an operation for drainage of an empyema or peritoneal abscess is to be performed, the possibility of postoperative chronic progressive gangrene of the skin should be kept in mind. Under such circumstances, suturing of the wound may predispose to this complication. During the postoperative period, the wound should be observed carefully and at the earliest sign of gangrene, the entire border, including normal skin, should be excised. Sulfonamides may be applied locally, although in our experience these drugs were of no value. After the infection is controlled and healthy granulation tissue is obtained, skin grafts may be applied to the ulcer.

SUMMARY AND CONCLUSIONS

An unusual case of extensive postoperative chronic progressive gangrene of the abdominal wall was observed. This may follow drainage of a deep abscess in either the peritoneal or pleural cavities, especially in older individuals where the wound has been sutured. Treatment consists of early wide excision of the ulcer margin, including normal tissue, replacement of

lost proteins from the gangrenous area and general supportive measures. Local applications of activated zinc peroxide or sulfonamides were of no value in this case.

Postoperative chronic progressive gangrene should be differentiated from a chronic undermining ulcer (Meleney) on a clinical basis by the gangrenous border and lack of undermining, and on a bacteriologic basis by isolation of the *microaerophilic nonhemolytic Streptococcus* and hemolytic *Staphylococcus aureus*.

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ANNOUNCEMENT

THE SAMUEL D. GROSS PRIZE

The Philadelphia Academy of Surgery has announced that competition is now open for the Samuel D. Gross Prize of \$1500. Essays will be received until January 1, 1945. The Committee members are Charles F. Mitchell, M.D., Calvin M. Smyth, M.D., and Damon B. Pfeiffer, M.D.

The conditions annexed by the testator are that the prize "shall be awarded every five years to the writer of the best original essay not exceeding one hundred and fifty printed pages, octavo, in length, illustrative of some subject in Surgical Pathology or Surgical Practice founded upon original investigations, the candidates for the prize to be American citizens."

It is expressly stipulated that the competitor who receives the prize shall publish his essay in book form, and that he shall deposit one copy of the work in the Samuel D. Gross Library of the Philadelphia Academy of Surgery, and that on the title page it shall be stated that to the essay was awarded the Samuel D. Gross Prize of the Philadelphia Academy of Surgery.

The essays, which must be written by a single author in the English language, should be sent to the "Trustees of the Samuel D. Gross Prize of the Philadelphia Academy of Surgery, care of the College of Physicians, 19 South 22nd Street, Philadelphia," on or before January 1, 1945.

Each essay must be typewritten, distinguished by a motto, and accompanied by a sealed envelope bearing the same motto, containing the name and address of the writer. No envelope will be opened except that which accompanies the successful essay. The Committee will return the unsuccessful essays if reclaimed by their respective writers, or their agents, within one year. The Committee reserves the right to make no award if the essays submitted are not considered worthy of the prize.



A PHYSIOLOGIC ANALYSIS OF THE NATURE AND OF THE TREATMENT OF BURNS

CAPTAIN WILLIAM W L GLENN, M C

ARMY OF THE UNITED STATES

THE PURPOSE of this communication is to discuss some of the local physiologic changes in and about burns and certain physiologic requirements necessary for the rational treatment of these injuries. On the basis of this discussion it becomes possible to review a method of treating burns designed to meet these requirements and proven efficacious both in the laboratory and in the clinic.

The local treatment of burns necessitates consideration of three fundamental lesions: (1) Injury to the epithelium, (2) injury to the vascular bed, particularly the capillaries in the burned area, and (3) injury to the surrounding and supporting tissues. Each is a distinct lesion characteristic of the tissue affected, and each is vitally concerned in the ultimate healing of the wound. Naturally, consideration of any one of these lesions requires appraisal and consideration of the other two. It is believed that the underlying cause for the lack of uniformity in the treatment of burns has been failure to appreciate this triad of lesions and the physiologic changes brought about by them. For example, injury to the epithelium is the most obvious lesion in burns, and the one which has received most attention is local therapy. But with this go increased capillary permeability and injury to supporting tissue.

THE GENERAL NATURE OF A BURN OF THE SKIN

In a burn the extent of injury to individual cells is relatively constant over an appreciable surface area, and beyond this there are cells damaged, more or less, dependent upon the length of exposure and the degree of heat applied. These gradations of injury interfere somewhat with experimental observations in which it is desired to create a very constant and repeatable burn. The inevitable differences in degree of injury are important, however, not only from the pathologic standpoint but from the physiologic standpoint as well, since degree and persistence of physiologic reactions will depend upon the severity of the pathologic changes in the tissue. Depending upon their severity, burns produce varying degrees of systemic effect, but the

cause, or causes, of these serious effects upon the patient have not been identified satisfactorily. Extensive studies on the blood have revealed but few changes in the known chemical constituents. Elevation of protein metabolism following severe burns has been known for some time. French workers¹ recognized a large amount of undetermined nitrogen in the blood of badly burned patients and attributed this to "polypeptides." Other workers^{2, 3} in this country doubt this suggestion. Taylor, and his coworkers^{3, 4} have recently made a thorough study of protein metabolism in severely burned patients. They attributed their findings of an irreversible azotemia with a large amount of undetermined nitrogen to an increased rate of protein catabolism plus a partially damaged kidney. They found this type of azotemia chiefly in patients who also showed hemoglobinemia and hemoglobinuria. They made the interesting and important observation that severely burned patients lost large amounts of nitrogen in the urine and that more than four times the normal protein intake was necessary to keep them in positive nitrogen balance. Perlmann, Glenn, and Kaufman⁵ described the appearance of a new globulin fraction in lymph collected directly from the burned extremity in calves. It is not known as yet just what significance can be attached to this finding, but it is certain that it is in some way related to the thermal injury and that the new globulin comes directly from the burned area. Muus and Hardenbergh⁶ have reported that lymph collected from lymphatic trunks draining severely burned skin and subcutaneous tissues in calves and dogs contains a substance which increases the oxygen utilization of slices of liver from normal rats. This substance is of unknown composition. It is not the globulin described by Perlmann, and her associates, since that compound does not affect oxygen utilization. The finding of something in the exudate from burns, which is precisely what the lymph utilized by Muus and Hardenbergh is, must prove of value in understanding both the local and the general changes induced by burns. Animals severely burned, but with no break in the skin, often display a mounting temperature and may die with hyperpyrexia 8 to 15 hours after the injury. The same observation has been made upon human patients and is in no way related to infection. The fact seems to be that if a burn is extensive enough and circulatory conditions, including the lymphatic side of the process, provide thoroughgoing absorption, something, perhaps essential for local healing, leaks over into the circulation and produces systemic effects which may be highly undesirable. One must keep this in mind in treating the shock so frequently attending severe burns, since the routine employment of external heat may be exactly the wrong thing to do, just as Blalock⁷ has demonstrated in the treatment of traumatic shock.

The loss of sodium from the blood into injured tissue has been suggested by Fox and Keston⁸ as the chief cause of the diminished plasma volume in surgical shock from all causes. Fox⁹ gave large amounts of 1.75 per cent sodium lactate orally to patients with "extensive full-thickness" burns. In view of the implied severity of the burns this would seem a favorable result,

but this form of treatment and particularly the evidence behind it require much more study before reliance can be placed upon them

SPECIAL CHANGES IN BURNS

1 THE EPITHELIUM

The primary function of the epithelium is protection of the underlying structures. The protective covering does not consist of the epithelium alone but, in addition, a much thicker and tougher layer between the epithelium and the subcutaneous tissue below. This subepithelial layer of skin is made up of white fibrous tissue containing in its meshes the capillaries and lymphatics of the skin and in addition the very important hair follicles, sebaceous and sweat glands. One of the first results of increased capillary permeability in the skin is the accumulation of extravascular fluid in the superficial tissue spaces beneath the basement membrane and ultimately, due to pressure from below, the epithelial layer is lifted off and a blister is formed.

Simple destruction of the epithelium constitutes a minor or second degree burn. The great majority of these if treated with any care whatever will heal uneventfully. Reepithelization arises from the margins of the wound and from the very important hair follicles in the deeper layers of the skin. Howes¹⁰ has shown by colored photography that reepithelization of a denuded area from the margins of a wound or from an island of epithelium in the wounded area proceeds at the rate of about 0.5 Mm a day after a latent period of four to six days. At such a slow rate, reepithelization of a large surface would take a very long time if it were to come from the margins of the burn alone. The preservation of the islands of epithelium in the hair follicles lying deep in the corium, undestroyed by the original injury, is a matter of great importance. The chief factors concerned in the destruction of these islands should be appreciated and every effort made to avoid them. They are, namely, (1) too active cleansing or scrubbing of the part at the time of the initial débridement, (2) the application of harmful local therapy,¹¹ (3) infection, and (4) inordinate swelling of the subcutaneous tissue with resultant stretching of the skin and anoxia of these cells, especially in poorly vascularized areas or in areas where the skin is very thin.

2 THE VASCULAR LESION

The effect of heat upon the finer blood vessels, arterioles, capillaries, venules, and arteriovenous anastomosing branches is of major importance in estimating the severity of burns and in understanding current therapeutic measures.

Essentially, the effect of heat upon capillaries, short of thrombosis and destruction, is dilatation with increase in permeability. The reaction in viable vessels is apparently brought about in two ways. First, through stimulation of the pain nerve endings in the skin, there is a dilatation of the adjacent capillaries and arteriovenous anastomoses in the burned and immediately adjacent tissue—the axone reflex. This is a reversible reaction

depending upon cessation of stimulation of the pain nerve endings. The nervous effect is perhaps due to histamine or histamine-like substances released as the heating of the tissue occurs. It is probable that still other and more stable chemical compounds, occurring in the injury as dead tissue is removed and recovery begins, are also dilator in effect and maintain the increased local blood supply far beyond the primary opening of the vessels. Local vascular changes such as these should be looked upon as essential provisions for healing, since they assure maximum oxygenation and supply of nutrient substances from the blood. At the same time, one may conceive (it is not proved) that if very severe burns release vasodilator compounds into the general circulation, even in small amounts, these same substances which are so essential locally may induce a general and extremely slight degree of increased permeability of capillaries which would assist in lowering plasma volume and inducing shock.

Second, and more important, there is the direct effect of heat upon the capillary wall. This, too, is reversible if the burning temperature has not been actually destructive. McCarrell¹² showed that if the temperature of the mucous surface of the nasopharynx did not get above 55° C dilatation and increased capillary permeability disappeared fairly promptly. Exposure to temperatures above this results in a progressive delay in recovery of the capillary endothelium. It has been demonstrated¹³ that viable capillaries injured in a severe burn ceased to leak abnormally in about six days following the injury, if no infection was present. Injury to the capillary endothelium by the application of heat is not the sole cause for the perpetuation of increased capillary permeability. Once swelling of the tissues has begun, capillaries present in loose tissue, where a large amount of swelling and stretching of the tissues may occur, tend to remain dilated through the stretching of their walls by the attached supporting tissues and through anoxia if any cause of stasis has been present.

A final factor that tends to perpetuate capillary leakage, and one that accompanies injudicious treatment of the shock that follows the initial fluid loss, is intravenous therapy. Harkins,¹⁴ Blalock,¹⁵ and others, have called attention to the disproportionate amount of fluid injected intravenously, even whole blood, that an area, with incompetent widely dilated capillaries, may receive. Salt solutions lacking protein are doubly injurious in that not only do they leak into the burned area in large amounts, but carry intravascular protein with them.

The changes in the amount and character of the extravascular fluid in the burned area as contrasted with sound tissue form a very important characteristic of burns and are directly related to the injury of the capillary endothelium. In burns one thinks of a large amount of tissue destruction. With this there should be a concomitant release of thromboplastic substance from the damaged cells with a resultant prompt clotting of the plasma-like exudate in the burned area. This conception would follow Menkin's theory of the localization of inflammation by irritants causing cell destruction.

and blockage of drainage by coagulation in the tissue spaces and lymphatics. It has been shown,¹⁶ however, that in burns caused by immersion of a part in boiling water, the extravascular exudate does not clot promptly but flows in profuse amounts through open lymphatics back to the general circulation. It is not until some hours later that general clotting of this exudate occurs. This delay in clotting or localization of the burn exudate may be due to one or all of the following factors. In the first place, in a burn there is often a delay in the breakdown of the killed and injured cells. This may be due, in turn, to sterile coagulation of cells, or to destruction by heat of the normally present preezyme in the burned area, as suggested by Whipple.¹⁷ In the second place, the comparatively minor burn to the deeper tissues even in a severe surface burn may result in widespread capillary dilatation without necessarily causing tissue destruction sufficiently severe for the release of thromboplastin. Although severe damage is done to the superficial tissues, the undersurface of the skin is amply supplied by capillaries which dilate widely, as is easily demonstrated by the intravenous injection of the colloidal dye T-1824 following a burn, and leakage from these capillaries passes easily into the loose subcutaneous tissue below, where, owing to little cell destruction, the supply of thromboplastin may be very small. The third factor is the finding in calves² of a great delay in the clotting time of lymph collected from a burned area in the first two to four hours after the burn. This suggested the possibility of an antithrombic substance produced in the burned area.

Prompt clotting of the extravascular exudate can be brought about at any time following a burn by the injection of thromboplastin, normal fresh muscle or other tissue ground in salt solution, into the burned area. Blockage of the lymphatics occurs immediately, with cessation of lymph flow. Capillary permeability does not stop, however, and the part swells even more rapidly as blockage of the return of the plasma-like exudate to the general circulation by way of the lymphatics has been accomplished. The swelling in the subcutaneous tissue is not confined to the burned area, but may spread for considerable distances through normal tissue as the pressure increases in the burned area. This spread is evident even when clotting of the burn exudate is prompt. Strict localization of the exudate is not possible even by artificially hastening and extending coagulation. Conversely, Glenn, Peterson, and Drinker¹⁶ found that by heparinization prior to burning so that no clotting could occur, there was negligible swelling of the part with almost complete return of the plasma lost from incompetent capillaries to the general circulation *via* wide-open lymphatics.

These remarks on the vascular lesion in burns and the extravascular exudate are important in many very practical ways. They indicate that capillaries are extremely heat sensitive, that they react to heat by dilatation, that their recovery may be delayed for many days, and during this time leakage from them can continue in abnormally large amounts, that the use of intravenous plasma or other solutions must be accompanied by realization of

then transient beneficial effects as long as the capillaries remain permeable, the apparent recovery from shock following intravenous therapy being only transitory with the patient slipping back into a dangerous state shortly after the plasma infusion is stopped. The failure of the extravascular exudate to be promptly and effectively localized by clotting allows for maximum absorption of abnormal substances from the burn into the general circulation during the first six to ten hours, together with soluble therapeutic agents applied locally, and for the spread of contaminating bacteria and their products. When clotting of the exudate has taken place it becomes a stagnant gel, acting as a foreign body slowly disposed of and requiring complete removal before healing can take place. In addition, this clotted plasma produces an abnormal environment for the surrounding tissue cells, mechanically stretching or compressing them, often, we believe, to the point of anoxia and death, especially in the superficial less distensible part of the skin. The subcutaneous mass of clot forms an excellent medium for the growth of bacteria, becoming the source itself of abnormal products, and finally acting as a support and source of nitrogen for the proliferation of fibroblasts with ultimate extensive scarring. Restriction of the volume of exudate is imperative in all burns.

THERAPEUTIC REQUIREMENTS

Physiologically, certain definite therapeutic requirements present themselves. Simply stated these are (1) A protective, noninjurious covering, (2) a method of control of capillary leakage, and (3) immobilization of the part.

It is not our purpose to discuss the pros and cons of eschars, simple non-pressure dressings, continuous or intermittent wet dressings. Suffice it to say that none of these methods meet either of the last two requirements and, therefore, do not furnish adequate treatment of fresh severe burns.

1 THE PROTECTIVE COVERING

Of fundamental necessity are. First, that the dressing does no further damage to the burned surface. Cannon and Cope¹¹ have shown the advantage of using a simple bland ointment. They found that epithelization was delayed when either tannic acid or triple dye eschars were used. For their observations they used a single donor site of a split-thickness graft taken with the dermatome. Allen and Koch,¹⁸ Siler and Reid,¹⁹ Cope,²⁰ and others, employed gauze thinly impregnated with boric ointment. Owens²¹ used sterile gauze soaked in physiologic salt solution, and, recently, Lund²² has found that grease of any sort is detrimental rather than advantageous on the thin layer of gauze laid over burned surfaces and covered by plaster of paris.

Second, the covering must afford protection from contamination, since infection is one of the most difficult problems in burns. Howes¹⁰ has shown that epithelial proliferation is greatly retarded by infection and that actual destruction of epithelium by bacteria or their products occurs. Hare²³ has

pointed out that a very dangerous source of contamination is from the unshielded noses and throats of persons attending these wounds. The recent work of the several clinics studying the effects of locally applied sulfonamides, reported by Meleney,²⁴ show that severe infections were twice as frequent in wounds with maximum initial washing as in those that had only minimum washing. This confirms the findings of Cope,²⁰ who practiced minimum débridement in the burns treated by him with satisfactory results. Levenson and Lund²⁵ have also employed minimum débridement with excellent results. It is important to note, however, that both Cope,²⁰ and Levenson and Lund,²⁵ employed types of pressure dressings and did not imply that their results would have been as good had they used eschars, where maximum débridement is a first necessity.

Third, the protective covering should require infrequent change. Howes¹⁰ has shown that frequent dressings injure delicate advancing epithelial cells. Lund²⁶ called attention to the severe pain occasioned by the dressing of burns. Orr²⁷ is perhaps the greatest proponent of the principle of infrequent change of dressings. The danger of contamination of incompletely healed burns by frequent dressings is of paramount importance, and such dressings are contrary to sound surgical principles in the treatment of open wounds. As Paracelsus, in 1536, so wisely expressed it: "Warily must the surgeon take heed not to remove or interfere with nature's balsam, but protect and defend it in its working and virtue. It is the nature of the flesh to possess in itself an innate balsam which healeth wounds."

2 THE CONTROL OF CAPILLARY LEAKAGE

In 1941, Rhoads, *et al*, reported the successful use of adrenal cortical extract in the treatment of capillary dilatation in burns. Recently, in 1943, these same authors,²⁸ reporting a much larger series of burns, came to the conclusion that as a routine measure adrenal cortical extract is not advised, as it does not control capillary permeability in the majority of burns. In an earlier part of this paper, the factors concerned in increased capillary permeability were discussed, and it is not surprising that such capillaries cannot be rendered normal by adrenal cortical extracts.

The credit for using external mechanical pressure as a means of controlling capillary leakage probably belongs to Blair,²⁹ who, in 1924, reported upon the efficacy of the pressure dressing in the successful grafting of skin. More recently, Allen and Koch¹⁸ have used a similar dressing in the attempt to control increased capillary permeability in burns, although this principle was recognized many years before. The introduction of a mechanical attempt to control capillary leakage in the burned area is believed to be the greatest single advance in the local treatment of these wounds. The type of dressing applied by Allen and Koch may be termed the *external* pressure dressings, since the pressure is dependent upon cotton elastic bandages applied firmly over a thick buffer layer of waste cotton, gauze, or sponges. This dressing

has been used successfully by many, chief among whom are Allen and Koch,¹⁸ Siler and Reid,¹⁹ Owens,²¹ Cope,²⁰ and others. Such a bulky dressing well applied also affords a fairly high degree of immobilization of the part. Its chief objection physiologically is that the treatment guesses at the amount of pressure necessary to control capillary leakage and consequent swelling. At best, the pressure applied is an estimate that will vary from operator to operator and from dressing to dressing. One must be careful not to produce either too much pressure or too little, the former is, of course, more dangerous than the latter. Another objection to this dressing is that it is difficult to hold accurately in the position of maximum function for prolonged periods without the danger of loosening of the bandage and loss of immobilization.

A second method of controlling capillary leakage by mechanical means is by use of a nonelastic and nondistensible dressing. This employs the principle of a rigid wall applied to conform exactly to the part as it exists at the time of the application. No external pressure whatever is used in the application, and the plaster of paris, the essential factor in the dressing, is as nearly skin-tight as possible, there being a very thin protective layer of gauze between the plaster and the burn. Thus, as plasma escapes from the dilated hyperpermeable capillaries the extravascular tissue fluid pressure quickly builds up against the rigid encasement to exactly equal the pressure attempting to push the fluid out of the capillaries. In other words, once this pressure equilibrium has taken place, no more fluid can leak from the capillaries than can be carried away by lymphatics draining the part or absorbed by the capillaries in the burned area. Glenn Gilbert and Drinker¹ applied plaster encasements to the paws of dogs following a burn caused by immersing the part in hot or boiling water for definite periods. The first experiments were designed to test the efficiency of the blood circulation beneath a perfectly fitting skin-tight plaster. Liquid dental plaster, with a hardening time of five to seven minutes, was used. The burned paw was dipped directly into the liquid plaster and the encasement allowed to harden about the foot. Thus, between the encasement and the capillary wall there was an incompressible watery medium, so that literally the wall of the plaster became the wall of the capillary. Experiments were carried out over periods of recovery lasting from six hours to 15 days. Following the hardening of the plaster, the encased foot was removed from the metal container, the plaster dried, and another perforated metal can was slipped over the plaster and held in place with glue to prevent the encasement from breaking as the animal ran about on it. Studies included

- 1 The testing of the skin temperature beneath the encasement over a period of 13 days, by the inclusion prior to encasement of a thermocouple next to the skin. There was at no time a decrease in the temperature in the burned and encased foot below that of the other unburned feet.

- 2 Measurement of venous oxygen in the veins from a burned and encased foot and a burned and nonencased foot. This revealed practically

identical oxygen saturation in both feet, and indicated a similar degree of dilatation of the capillary bed

3 Measurement of lymph flow from a burned and encased foot and from a burned and nonencased foot The drainage from the nonencased foot was much more profuse and indicated a greater number of open lymphatics in the stretched tissue of the nonencased foot as well as a much greater leakage of plasma from the capillaries in the nonencased foot In addition to the decrease in the amount of lymph flow, there was a much more rapid blockage of the lymphatics and cessation of lymph flow from the encased foot, although in it the total amount of clotted exudate was minimal Both of these factors are of considerable importance for absorption *via* the lymphatics in the early hours following a burn and the accumulation of large amounts of clotted subcutaneous exudate later on, as pointed out earlier in this paper

4 Measurement of the end-lymphatic pressure in a burned and encased foot and a burned and nonencased foot showed that the pressure in the encased foot rose promptly to systolic blood pressure and varied only with systolic pressure The pressure in the nonencased foot rose slowly, and usually some blockage of the lymphatics had occurred before maximum pressure readings were obtained It is to be remembered that in the nonencased foot there is much room for dissemination of pressure through distention of the tissues, but unlike the encased foot the increased pressure is accompanied by stretching of the tissues These experiments indicated to the authors that the pressure necessary to control capillary permeability was dependent upon the systolic blood pressure at the time the part was enclosed in a rigid dressing, and that this pressure was rapidly reached in the extravascular tissue spaces soon after the rigid dressing was applied

5 Animals were allowed to survive with the encasements in place for one to three weeks There was apparently no pain whatever and reepithelization of the part occurred with great rapidity, with little or no scar tissue and no deformity even in very severe burns (45 seconds in 100° C water) The plaster encasement dressing was changed to the roller bandage plaster dressing and a number of equally successful experiments were carried out Some points in the application of plaster necessary for the success of this technic are mentioned in the last section of this paper

3 IMMOBILIZATION

The effect of motion on the movement of lymph and tissue fluids is well known Drinker and Field³⁰ clearly proved that lymph flow is greatly enhanced by motion of any sort Barnes and Trueta³¹ performed a group of experiments in which they showed that toxic substances of sufficient molecular size not to be absorbed by the capillaries were prevented from reaching the general circulation in lethal doses *via* the lymphatics by immobilization of the injured part Orr, again, is the great classical proponent of immobilization in the treatment of chronic infections Lyons³² felt that immobilization was largely responsible for the control of bacterial invasion

in a group of burns treated by minimum debridement. In burns, because of the possibility of deforming scars, the part should be immobilized in the position of maximum function. Contrary to the belief of some, immobilization over a period of three to six weeks does not result in contractures and difficulty in restoring function. Glenn, Gilbert, and Drinker found in their animals, and Levenson and Lund found in their patients, a very prompt restoration of normal function after immobilization for three to six weeks in plaster dressings. It is believed that early motion in burns is contrary to the principles governing healing of these wounds, and that until healing has taken place motion should be avoided and replaced by prolonged and complete immobilization in the position of maximum function.

4 THE CLINICAL USE OF CLOSED-PLASTER DRESSINGS

The aim of the animal experiments of Glenn, Gilbert, and Drinker¹³ was to explore and demonstrate the physiologic requirements of local therapy. The actual application of these principles to human burns depended upon clinical trial and judgment.

Plaster application lends itself best to burns of the extremities. From the experience of Levenson and Lund,²⁵ and Barnes³³ it is probable that the clinical use of this method will be largely confined to the arms and legs, although others have applied encasements elsewhere. The after effects of severe burns of the hands are the most disabling injuries thermal agents can produce, and the use of plaster dressings in these cases is particularly indicated.

Glenn, Gilbert, and Drinker called attention to certain essentials in the application of the plaster dressing in burns that they had learned from the use of this dressing upon animals. They suggested that these principles be followed for the successful use of this technic in human burns.

- 1 The application of plaster must be with the minimum of padding, and *absolutely without* pressure. It is molded gently to the part.

- 2 The application of plaster to an extremity must extend entirely over the end of the extremity whether the end is burned or not. If this is not done, swelling distal to the encasement will occur and gangrene may result. This swelling is a result of relatively high venous and tissue pressure beneath the encasement. Venous blood in the normal area is under normal pressure and cannot return through the high pressure region beneath the encasement. At the same time, arterial blood can get through beneath the encasement into the normal part, and a one-way tourniquet with its disastrous effects results. Encasement of the normal area in the plaster bandage prevents this from happening as pressure beneath the plaster is equalized and no blockage of the venous return occurs.

- 3 The application of plaster must extend above the upper margin of the burn or swelling for a distance of two to four inches, otherwise a wedge of subcutaneous edema will develop at the upper end of the encasement, and marked swelling proximal to the encasement will occur.

Closed-plaster dressings have been used in human burns for the past ten years, but without full appreciation of the nicety of the method or its correct application. References to the literature will be found in papers by Barnes,³³ who has reported on the use of plaster similar in most respects to the method described in this report, and by Levenson and Lund²⁵ who have recently described the use of plaster dressings in the treatment of fresh burns of the extremity. Their work is of singular importance for they applied the plaster with an exact knowledge of what they wished to accomplish, which had been gained from experiments upon animals.

SUMMARY AND CONCLUSIONS

The outstanding points in the application of plaster to human burns as brought out by Levenson and Lund,²⁵ Barnes,³³ and my own observations are

- 1 There is no local harm from this treatment
- 2 There were no instances of injured circulation. Some may object to the application of plaster to a part that is certain to swell. In burns it is not the control of massive local hemorrhage through rupture of large vessels that one attempts to stop, but plasma leakage through a widely dispersed capillary bed. The safest way to restrain leakage seems to be complete encasement of the part in rigid plaster which holds blood vessels within the size present at the time of application and does not compress them by added increments of external pressure.
- 3 The prompt return of function of a part immobilized in plaster over prolonged periods has been one of the most gratifying features of this treatment. Recently, Levenson and Lund have been leaving their original dressing in place for as long as four weeks. Upon removal of the encasement, the return of full motion of the fingers or other points encased in plaster has been very rapid, requiring only a day or two.
- 4 Not the least important is the comfort obtained by this treatment. In nearly every instance the application of the initial dressing has been followed by a very prompt relief of pain. Occasionally, after a day or so, the patient may complain of a slight dull ache in the burned area. This does not persist, as a rule, and may be relieved by elevation, as suggested by Barnes,³³ and referred to in paragraph 8 in this summary.
- 5 Levenson and Lund found that the plaster dressing is easy to apply to human burns of the extremity. It is their impression that it can be applied more quickly and with more accuracy than other forms of pressure dressings they have used. Likewise, it is easier to teach others to apply.
- 6 The slight degree of after care of the burned area is one of the chief advantages of the plaster treatment. It is testified to by the practice of leaving the original dressing in place for as long as four weeks in severe burns. Patients with burns confined to the upper extremities may walk about or even be discharged from the hospital to come back for change of dressings. The importance of infrequent dressings of burns cannot be too greatly emphasized. Usually what prompts a change of dressing is not

the presence of definite clinical indications that local interference is necessary, but simply curiosity as to "how things are doing" Such curiosity must be restrained if one hopes to improve the treatment of these wounds Not only is it not helpful, but it is definitely dangerous and injurious

7 Débridement is minimal, with removal of only gross dirt and loose skin No blisters were broken and sulfonamides were not used locally Infection has proved localized and superficial Fever, in burns limited to the hands and arms, was strikingly absent

8 It is profitable to call especial attention to a statement in Barnes's³⁰ paper He noted that pain or discomfort in an encased extremity occurring 24 to 36 hours after application of the dressing was relieved by elevation of the part This simple observation calls attention to one of the causes of pain due to burns, namely, the process of distending and stretching the tissue and the sensory nerve filaments within them Sensations interpreted as pain are most readily caused by change of stimulus at the site of impulse reception That is, an irritant upon, or in, the tissues may cause pain when first introduced but if the irritant remains exactly as applied pain gradually disappears If pain is continuous or reappears after a period of comfort, something progressive, some sort of change has taken place This fact applies directly to the closed plaster treatment of burns A badly injured part subjected to plaster encasement is covered by a single layer of gauze and then by plaster of paris so as to hold it at exactly the volume existent at the moment of application and so as to prevent motion The result of this prompt restraint of swelling and motion is to remove possible changes in state which will be perceived as pain But let us suppose the surgeon has used a number of layers of gauze beneath the plaster In a short time the part will swell so that no further change in volume is possible Swelling ceases and pressure becomes equal through the part At the same time the local hyperemia and abnormal leakiness of capillaries continues though actual release of fluid from them with storage in the tissues is prevented

Recovery of capillaries will be progressive, those at deepest levels and heated least becoming normal first, and those nearest the surface and still viable being abnormally leaky for about a week If, after 24 hours, the part is placed in a position which lowers venous pressure, it may begin to shrink away from the plaster, and then if it has happened to become slightly dependent discomfort or pain may occur as it swells to fill the plaster casing The same sort of analysis may be applied to burns received for treatment some hours after their occurrence Swelling may already be maximal In this case, the part should be elevated during the initial brief examination and cleansing and the plaster dressing applied After this some degree of elevation may well be continuous for the first week, so that no preventable element of increased venous pressure may arrest shrinkage of the part under the plaster or cause abrupt increases in volume In such cases it may be well to consider the use of the conventional pressure dressing with the idea that even though one cannot know much about the pressure used or its consequences in

restricting capillary blood flow, it may be advantageous to employ an elastic covering which follows the size of the part. These are matters for further careful examination both in laboratory and clinic.

9 At the present time these directions for using closed-plaster dressings in the treatment of burns may be followed. After minimal cleaning and débridement and without breaking blisters, two layers of sterile gauze are laid over the burned surface extending above the area to be covered by plaster. If fingers are involved they are enclosed separately in the gauze. A thin sheet of roller plaster bandage is then applied to the part without pressure, extending over the end of the extremity and two to four inches above the burn. In mild burns the encasement is removed in seven to 14 days. In more severe burns it may be left in place for as long as four weeks. If the burn is incompletely healed or the epithelium is very thin, another encasement should be immediately reapplied. Grafting may be started as soon as the slough separates.

Numbness beneath the plaster is a positive indication for prompt removal. No cases of this have yet been observed, and if the principles for the correct application are adhered to, none should develop.

Infection beneath the encasement is usually well localized, and as a rule does not warrant removal of the encasement. Sulfonamides upon the burned surface are, at best, of questionable value.

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THE NUTRITIONAL CARE OF CASES OF EXTENSIVE BURNS*

WITH SPECIAL REFERENCE TO THE ORAL USE OF AMINO-ACIDS (AMIGEN)
IN THREE CASES

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THE NUTRITIONAL STATUS of extensive burns may be discussed under three headings Loss of nitrogen, the change in plasma protein levels, and the nitrogen intake, which may include delayed blood and plasma transfusions

Loss of Nitrogen Lucido,¹ in 1940, published his metabolic studies on a case of burn estimated as involving 40 per cent of body area He reported that the patient had a high urinary excretion of nitrogen for the first 25 days following the burn An analysis of his published chart reveals that the output of urinary nitrogen was not consistent The variations which occurred from day to day ranged between a maximum of 28 and a minimum of 10 Gm per day Browne² studied the nitrogen output in three cases of burns, one complicated by a fracture On a regular diet all showed an elevated urinary output to as high as 28 Gm per day, gradually dwindling down to normal on the 40th day to the 52nd Taylor, Levenson, Davidson, Adams and McDonald,³ in 1943, reported an excretion of as much as 45 Gm of nitrogen in 24 hours, and called attention to the nitrogen deficit which would inevitably result from the cumulative loss Cope, Nathanson, Rourke and Wilson⁴ found that the level of nitrogen excretion in most cases of burns was comparable to that which occurs in normal persons, the highest amount which they reported being 22 Gm (calculated from their published charts) The negative nitrogen balance was attributed by these workers to low intake, and the fact that the amount of nitrogen excreted was small appeared to be referable to absence of infections Taylor, Levenson, Davidson, Browder and Lund,⁵ in a later communication, reported one case of extensive burns involving 45 per cent of the body surface in third-degree, and 10 per cent in second-degree burns, who excreted as much as 34 Gm of nitrogen in the

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urine on some days. His published chart, when analyzed, showed an average excretion of 27.5 Gm daily the first week, gradually declining but not reaching normal until the seventh week. None of these authors mentioned the possibility that the large early loss might be partly accounted for by hemoglobinuria, which was reported by Lucido and Taylor, and associates, as being present in their cases.

The Plasma Protein Level The serum protein level in Lucido's case was 4.9 Gm per cent on the third day following the burn, and gradually rose to between 5-6 Gm per cent during the subsequent period of observation. Cope, *et al*, reported a total plasma protein level of 5.5 Gm per cent for a burn involving 11 per cent of body surface on the 39th day. In the case reported by Taylor, *et al*, the level of total plasma protein fell to 3.1 Gm per cent. Only 1.6 Gm per cent of albumin was present, accompanied by massive edema, until strenuous efforts were made to increase the protein intake, when the level rose to only 6 Gm per cent. These protein figures observed in the latter stages of burns clearly demonstrate the presence of hypoproteinemia.

In a still more recent communication, Taylor's group⁶ showed that of 81 patients with burns who were studied, 40 had hypoproteinemia. This condition, moreover, seemed to have a definite correlation with the severity of the burns. In 12 having burns affecting between 10 and 50 per cent of the body surface, eight, or 75 per cent, showed progressive hypoproteinemia. In 51 cases with burns involving less than 10 per cent, however, eight, or 15 per cent, showed a reduction in the amount of plasma proteins.

The Nitrogen Intake The maximum nitrogen intake of Lucido's case was 120 Gm of protein (19 Gm N) toward the end of his study period. Cope, *et al*, cases had intakes of from 10 to 32.5 Gm of nitrogen per day, the latter figures being made up mostly of large transfusions. In Taylor, *et al*, cases, the intake fluctuated between 35 Gm of protein to 100 Gm a day, until the 12th week, when the low plasma protein mentioned above was found and "the clinical condition was desperate." Then the intake was increased by administering additional protein in the form of 75 Gm of albumin units and several units of desiccated plasma intravenously and *per os* through a stomach tube. On some of the days of special treatments, the protein intake was as high as 500 Gm.

In regard to the problem of protein intake, Taylor's group,⁶ in their most recent paper, state that

"In all burned patients admitted to this hospital, an attempt was made to meet the demand for protein by increasing the protein intake to from 100 to 125 Gm a day. Even at this level, there was a marked negative nitrogen balance in nine patients with severe burns. Most of the patients with minor burns of less than 10 per cent of the body surface involved responded to the intake of 125 Gm of protein a day with a return of their plasma protein to normal, but in those patients with a continued marked loss of nitrogen into the urine, this did not occur. Indeed, in some of the severely burned patients, it has been calculated that on the basis of the loss of nitrogen into the urine alone, 300

Gm of protein a day would have been required to maintain nitrogen equilibrium. In addition to this loss, some patients continued to lose large amounts of nitrogen material from the burned surface for long periods of time. This insensible loss could not be calculated. The restoration of protein under these combined circumstances was a difficult problem, since the amounts required were considerably greater than those the patients could ingest."

The present work deals with the nutritional care of three cases of thermal third-degree burns of, respectively, 10, 30 and 50 per cent of body surface. The administration of a high caloric and high nitrogen intake as amino-acids (amigen) *per os* sufficed to maintain nutrition. The nitrogen balance was followed, for a varying period of time, throughout convalescence and the plasma proteins and body weight were determined periodically.

CASE REPORTS

Case 1—J. C., male, age 53 (Table I), was admitted, February 7, 1943, with second- and third-degree burns of both hands and third-degree burns of face and head. On entrance, his burns were sprayed with sulfathiazole solution in another hospital, but on the next day he was transferred to the Bellevue Hospital where debridement was performed and vaselined gauze applied. On February 12, 1943, when he came under the care of the Nutrition Service, he had lost 4.5 Kg, his hematocrit was 48, and plasma protein level 4.7 Gm per cent, cephalin flocculation test 3++++. He was given 500 cc of plasma and immediately put on a diet consisting of 35 Gm of nitrogen in the form of amigen, his caloric intake being 4500 daily. This intake was maintained with but slight variation throughout his stay in the hospital, a period which ended April 14. His nutritional state was excellent throughout his recovery. Thus, on February 23, ten days after he was placed on this diet, his plasma proteins had risen to 6.63 Gm per cent, and his weight was 55.7 Kg, which was only 0.8 Kg below his initial weight of 56.8 Kg. On April 14, with most of the burned areas healed, he weighed 62.5 Kg, or 5.7 Kg above his initial weight.

TABLE I

J. C. male 53 yrs admitted 2/7/43 2nd-3rd degree burns both hands 3rd degree face and head
Nitrogen Output

Date	Caloric Intake	N Intake Gm	Urinary N Gm	Dressing Gm	Total		Fecal N Gm	N Output Gm	N Balance Gm	P P Gm		Hem	Wt Kg	Remarks
					N	Gm				Per Cent	A/C			
2/6	Burned when falling into a fire, 10 per cent body surface, sprayed with sulfathiazole sol													
2/7	Débrided													
2/12-14	9 756	74	24 33			4 42	28 75	+45 75?	4 7	48	52 2	2/12	500 cc plasma ceph flocc	
													+++	
2/14-17	13 250	99	51 98			6 63	58 61	+73 39?	2/15	2/15	2/17	2/17	ceph flocc	
									6 39	47	53 7		neg	
2/17-20	14,610	106 2	47 61			6 63	54 24	+48 36?	2/17	33				
									5 44					
3/20-23	14,610	106 2	36 79			6 63	43 42	+62 78?	6 63	2/23	2/23	Hb 13 Gm		
										38	55 7			
3/23	14 610	106 2									58 8	Areas healing, excess granulat in some areas		
4/14	14 610	106 2							7 2	45	62 5	Referred plastic surgery for an old injured finger		

Case 2—J McN, male, age 42 (Table II), was admitted June 29, 1943, with second- and third-degree burns on the right side of the trunk to midthigh, involving 30 per cent of body surface. He was debrided and vaselined dressings were applied. His weight on June 30, when his metabolic studies began, was 55.45 Kg. For the first five days, he received 24 Gm of nitrogen and a caloric intake of 2600 a day. His urinary output during this period was roughly 175 Gm per day, making an apparent positive nitrogen balance of 65 Gm. On the basis of these figures, he could afford to lose 65 Gm of nitrogen per day in his exudate without utilizing his body nitrogen. This amount of intake was apparently insufficient, for his body weight on July 5 had fallen to 53.7 Kg. From July 4 to 7, his nitrogen intake was raised to 256 Gm, and in the period between the 7th and the 10th to 315 Gm, but his weight had fallen to 50.9 Kg by the 10th. From the 10th on, his intake was raised first to 336 Gm and then to 422 Gm, and this latter intake was maintained until his discharge on October 2. On this increasing intake, his weight first stayed stationary and then went up, regaining and then, finally, topping his entrance weight. His plasma proteins showed a corresponding rise. His nutritional state was excellent throughout the rest of the convalescence.

TABLE II

J McN male age 42 2nd and 3rd degree burns rt side of trunk to midthigh (30 per cent of body surface)
Nitrogen Output

Date	Caloric Intake	N Intake Gm	Urinary N Gm	Dressing Gm	Total N Output		N Balance Gm	P P Gm		Per Cent	Hem	Wt Kg	Remarks
					Fecal N Gm	N Gm		A/G	Gm				
6/29-7/1	5 240	48	31 79		1 64	33 33	+14 67?	6/29	6/29	6/30			Vaselined gauze dressing
7/2-7/4	7 496	66	57 56		2 31	59 87	+ 6 13?	4 96	48	7/2		55 45	DTs
7/4-7/7	8 090	78	64 5		2 31	66 81	+11 19?	7/2	42			7/5	
7/7-7/10	9 770	94 5	55 35	15 46?	2 31	57 66	+36 84?					53 7	
7/10-7/13	10 520	100 7	70 03		2 31	72 34	+21 16?	7/12	7/12			7/10	7/9 Burned areas
7/13-7/16	10 800	126 6	52 52		2 31	54 83	+65 67?	5 89	45			50 9	healthy
7/16-7/18	7 200	84 4	37 57		1 54	39 11	+40 29?					7/15	1 6 epithel
7/16-7/20				14 22?				7/19				7/19	7/20 40 per cent
								6 02	41			50 7	healed
7/22-7/17				14 92?				7/25	7/25	7/27	7/23	51 8	50 per cent
8/3								6 92	47			51 8	healed
8/2-8/ 7				4 44?								55	80 per cent healed
8/27												55	
10/2												57 5	Healing complete

Attempts were made to collect the exudate from the burned surface. Since a great deal had seeped through the gauze dressings into the bedclothes, the nitrogen loss into the dressings is at best a minimum figure. It was 5.15 Gm per day for the 8th to the 11th days.

Case 3—M W, colored, female, age 38 (Table III), suffered second- to third-degree burns on the trunk, right arm, buttocks, and left thigh on February 8, 1943. The burned area was estimated as involving 50 per cent of body surface, 90 per cent of the burns being third-degree. Her normal weight was 65.9 Kg. She was admitted in shock, was debrided, and tannic acid solution was applied. Between the date of her admission and April 16th, when she came into the Nutrition Service, she had 15 whole blood transfusions. She was also on the regular ward diet consisting of approxi-

NUTRITIONAL CARE OF BURNS

mately 10 Gm of nitrogen. On her admission into the Nutrition Service, her blood pressure was 90/50, and she was in very poor nutritional state, with a total plasma protein level of 4.31 Gm per cent, hemoglobin 8 Gm, hematocrit 40. A 500-cc transfusion of plasma was given. During the first three days of controlled study, she excreted 16.13 Gm of nitrogen in her urine, averaging over 5 Gm a day, a starvation level of excretion. She was then placed on 27.44 Gm of nitrogen a day for three days, then increased to 36 Gm daily for four days. Her urinary nitrogen during these two periods rose to 9 Gm a day. Her apparent positive nitrogen balance rose from 3.5 to 24 Gm a day. Her plasma proteins were 5.25 Gm per cent, her hematocrit stayed at 39, and she showed no perceptible improvement, her weight on April 13th being 50.7 Kg.

TABLE III

M W female age 38 2nd-3rd degree burns trunk rt arm buttocks left thigh preburn wt 65.9 Kg
Nitrogen Output

Date	Caloric Intake	N Intake Gm	Urinary N Gm	Dressing Gm	Fecal N Gm	Total		P P		Wt Kg	Remarks
						N Output Gm	N Balance Gm	Per Cent A/G	Hem Gm		
2/8-2/9	Burned on 2/8, 30 per cent surface area admission B/P 40/15, débridement and tannic acid spray										
2/9-4/6	15 blood transfusions 500 cc each, regular ward diet										
4/6-4/9	6 300?	30?	16 13				13 87?	5 31	40	50 9	Hb 8 Gm
4/9-4/12	9 465	82 32	23 96				59 36?				
4/13-4/17	15 135	143 85	37 73				106 12?	4/15		4/13	No perceptible improvement
								5 25	39	50 7	
4/18											500 cc blood—25 per cent burned area grafted
4/19										51 3	Condition improving
4/21-4/23	9 500	99 00	18 94				80 06?	4/23	35		500 cc blood—80 per cent grafts taking
								6 19			
4/28-4/30	9 500	99 00	14 18				83 82?				
5/2											Improving slightly
5/8-5/11	19 900	198	52 62	19 34?			145 38?				
5/17	6 550	66								53 57	Improving rapidly
6/15	6,550	66						6 8	42	59	Hb 11 Gm L thigh and buttocks graft
6/30-7/22	6,550	66									Rt shoulder and arm grafted
7/30	6 550	66								61 8	All grafts taking
8/10	6,550	66									
8/25	Amigen discontinued, put on high protein diet										
9/15										63 6	Most areas healed

She was given a blood transfusion in order to prepare her for the application of skin grafts to one-quarter of her burned area. Soon after the skin grafts were applied, her blood pressure fell to 80/40, a shock-like state which persisted until a blood transfusion was given. The significance of this will be discussed later in the paper. Her intake was increased to 35.77 Gm daily and this continued for six days, i.e., until April 19, when she began to improve and to show some gain in weight which was then 51.3 Kg. Her appetite improved and her intake was increased to 49.5 Gm daily, at first, and then to 66 Gm, on which she improved rapidly, so that on May 17 her weight was 53.57 Kg. It may be mentioned that the exudate from the burned areas collected in the dressings in the four-day period between May 7 and 11 was found to contain 19.34 Gm of nitrogen, or roughly 4.84 Gm daily. These, again, are minimum figures since some of the exudate was lost by seepage through the dressings. This minimal figure does not represent the amount lost in the areas not covered by the grafts, roughly, now 40 per cent of the body surface. On June 15, her plasma proteins were

68 Gm per cent, and her weight 59 Kg, and hemoglobin 11 Gm per cent. From then on, she ceased to be a nutritional problem.

DISCUSSION It appears that cases of burns of any appreciable extent of body surface tend to develop a state of malnutrition. The necessity for transfusions after the acute period is passed may be taken as rough index of the nutritional state of burn patients. Of the 38 cases reported by Cope's group, only five with burns over 20 per cent reached convalescence. On four of these the extent of the burned area ranged from 24.5 to 29 per cent of the body surface. The latter group required delayed transfusions of one to five units. The only instance on whom the blood protein level was reported was on a case in which 11 per cent of body area was involved. The plasma proteins on the 39th day were 5.5 Gm per cent. In our Case 2, J. McN., in whom the burned area comprised 30 per cent of the body surface, as much as 4.5 Kg was lost during the ten days following the accident. A plasma protein level of 4.48 Gm per cent was noted on the third day and nutrition could not be maintained on 25.6 Gm of nitrogen daily, an amount exceeding that of a classical high protein diet. Of the three cases available for study in whom over 50 per cent of the body surface was involved, Cope's case needed 25 transfusions during convalescence, and, inferentially, must have been in a precarious nutritional state. Taylor's case had lost 55 lbs by the end of the third week, although already showing some improvement. The poor nutritional state of our Case 3, M. W., needs no comment. And in their latest paper, Taylor's group⁶ reported that a loss of as much as 30 per cent of the body weight had occurred in some of the patients studied as a result of failure to maintain adequate nutrition.

When it is considered how many sources of nitrogen loss are present in burns, this poor nutritional status is understandable. There are at least four, perhaps five, avenues for this loss: (1) The intratissue loss into the burned areas, which may or may not be recoverable by the body, (2) the loss occurring in the exudate, (3) the loss as a result of hemoglobinuria, (4) the loss as a result of poor caloric and nitrogen intake consequent to anorexia, and (5) the possible loss due to a "antianabolic period" as a result of altered hormonal physiology.⁷

In this connection, Clowes, Lund and Levenson⁷ reporting on 150 cases of burns, 109 of whom were victims of the Coconut Grove disaster, stated "All patients with 10 per cent of surface area or more involved in third-degree burns became serious nutritional problems because of the loss of nitrogen in the urine and from the surface, and because of the increased nutritional requirements resulting from infection with fever."

Two preliminary attempts on our part to determine the protein loss in body exudates more quantitatively than in Cases 2 and 3 may be mentioned to illustrate how large this loss may become. Slabs of fine-pored cellulose sponges were used to collect the exudates. One case exuded as much as 0.42 mg of nitrogen per square centimeter in 24 hours, while another case

of denuded surface due to avulsion, exuded as much as 2.26 mg nitrogen per square centimeter. If half of the body surface of a man weighing 70 Kg., and 170 cm in height, were to be involved in a burn, the 9.050 sq cm so involved would lose, according to one rate, 3.8 Gm and according to the other rate, 19.9 Gm of nitrogen in 24 hours. Three point eight grams of nitrogen would be 23.75 Gm of protein, or the equivalent of 4,000 cc of plasma, or of 114 Gm of meat, and 19.9 Gm of nitrogen would be equivalent to 124 Gm of protein, over 2000 cc of plasma, and 600 Gm of meat.

The problem of keeping Case 1 in good nutrition was relatively simple. Cases 2 and 3 were somewhat more difficult. As it happened, the amount of nitrogen in the form of amino-acids fed to these three cases of increasing severity seemed to present a trend quantitatively in keeping with the extent of burns. Case 1 was kept in good nutritional state by 35 Gm of nitrogen in the form of amino-acids. How much less might be required we are not in a position to know. Case 2, however, with the 30 per cent area burns could not be kept in good nutrition by 25.6 Gm of nitrogen, while 33.6 Gm maintained him, and with 42.2 Gm he registered a rapid gain. Case 3 was not maintained by 36 Gm, but was maintained by 49.5 Gm, and registered a rapid gain with 66 Gm. It is quite possible that, as in the case of 35 Gm for Case 1, so might 42.2 Gm and 66 Gm be supra-optimal for Cases 2 and 3. Table IV shows these amounts and their conversion values into meat and plasma. The amount of transfusion used in these cases was minimal, being *nil* in Cases 1 and 2, and only three transfusions were administered during the entire period of nutritional study in Case 3. It will be seen from the conversion table (Table IV) that to maintain a patient in good nutritional state under circumstances similar to our patients in Cases 2 and 3 with either meat feeding or plasma transfusion is almost an impossible task physically and economically.

TABLE IV

Patient	Original Body Wt Kg	Area Burned Percent	Total Daily N Intake Gm	N in Gm Wt Kg	Total Equivalents			Remarks
					Proteins*	Meat*	Plasma*	
					Gm	Gm	Cc	
J C	56.8	10	35	0.62	218.75	1093	3644	Sufficient
J McN	55.45	30	24	0.43	130	750	2500	Insufficient
			25.6	0.46	160	800	2650	Insufficient
			33.6	0.61	210	1050	3500	Maintenance
			42.2	0.76	263.75	1318.75	4400	Rapid gain
M W	65.9	50	27.44	0.42	171.5	857.5	4570	Insufficient
			36	0.55	225	1125	3750	Maintenance
			49.5	0.75	309.4	1485	5160	Slight gain
			66	1.00	412.5	2062.5	6875	Rapid gain

* Conversion table of nitrogen intake into proteins, meat and plasma. The assumption is made that meat contains 20 per cent protein and the plasma as now prepared, contains 6 Gm per cent of proteins.

Thus, to feed a patient meat equivalent to the nitrogen intake of Case 3, M W, would require the daily ingestion of about two kilograms of meat,

an impossible task To give this amount of proteins in the form of plasma transfusions would require 23 units of plasma daily The amigen corresponding to this nitrogen intake costs in the neighborhood of three dollars The corresponding amount of meat would cost at least four times as much, while the cost of a corresponding amount of plasma would be prohibitive

For this reason preparations, such as amigen, used in the three reported cases appear to be the solution to the problem of nutritional care in severe cases of protein drain The rather logical way in which the dosages of amino-acids corresponded to the extent of the burned areas raises the hope that it might be possible to work out a practical formula of amino-acid feeding for burns of different extent

The development of shock following immediately upon the first skin grafting in Case 3, M W, is a phenomenon which may have an important bearing on the safety of this procedure in cases of extensive burns Her plasma protein level at this time was 5 Gm per cent Theoretically, it is to be expected that in patients undergoing severe protein loss with protein synthesis barely keeping up with the loss, the opening up of new areas of the skin surface, with resulting increase in exudation and bleeding, would readily lead to the development of shock If this explanation is correct, then patients in this condition should have no skin grafting attempted unless the protein nutrition has been improved and measures for the therapy of shock are at hand The increase of the exudative surface would be at the highest point during the first two days before the graft has taken Even after that, if all the graft has taken, the contraction of the graft would prevent this graft in the early stages from compensating for the exudation from the new donor areas

SUMMARY AND CONCLUSIONS

- 1 The nutritional status of three cases of second- and third-degree burns involving, respectively, 10, 30 and 50 per cent of body area, given high caloric and high nitrogen feedings in the form of dextrimaltose and amigen were studied

- 2 All three patients were maintained in excellent nutritional state

- 3 There seemed to be a mathematical relationship between the extent of surface burned and the amount of nitrogen required to maintain nutrition

- 4 Transfusions were reduced to a minimum

- 5 Preparations such as amigen seem to be better tolerated and utilized than natural protein food and appear to be the solution to the problem of nutritional care of severe cases of protein drain

- 6 The increased danger to patients with severe protein deprivation of the development of shock as a result of additional protein loss consequent upon opening up of new exuding areas in skin grafting has been discussed

Grateful acknowledgment is made of the help of Dr Stanley Sarnoff in suggesting the use of cellulose sponges for the collection of exudates and of that of David Gould in performing the polar planimetry

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ADENOMATOSIS OF ISLET CELLS, WITH HYPERINSULINISM*

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WE have already reviewed (Whipple and Frantz, 1935) the studies which led to the recognition of islet cell tumors. Beginning with the original observation of Ssobolew, published at the same time as Schulze (1900), that ligation of the pancreatic duct was followed by disappearance of the parenchyma of the gland with the exception of the islets, there came in close succession a series of publications on hypertrophy of the islets in diabetes.

In 1904, Ssobolew described an hypertrophied islet in a diabetic. In 1905, Herxheimer found hypertrophy of the islets in five diabetics, and MacCallum confirmed this in two cases in 1907, and considered it compensatory. Cecil (1909) studied the pancreas in 90 cases of diabetes and found hypertrophy also. Dubreuil and Anderodias (1920) reported striking hypertrophy of the islets in a newborn child of a diabetic mother, and, in the same year, Horgan, in 262 autopsy specimens of chronic diseases of the stomach and biliary tract, looked for neoplastic changes associated with chronic pancreatitis and described three stages of hypertrophy of the islets, which he designated as primary, secondary, and tertiary "adenocytoblastoma." In the tertiary stage he showed migration of cells through the connective tissue capsule, and considered this an "early neoplasia." In 1925, Boyd and Robinson described regeneration of islets in an insulin-treated case of diabetes—a child of nine with an accidental death and postmortem examination. In 1926, Gray and Feemster reported compensatory hypertrophy and hyperplasia of the islets in another newborn infant of a diabetic mother. Womack and Cole (Case 2) (1937), reported a similar infant case, as did Bauer and Royster in the same year. This case was associated with tetany, and their report included a review of the literature. Somewhat contradictory conclusions have been reached by Potter, Seckel, and Stuyker (1941). In discussing hyperplasia and hypertrophy of the islets of Langerhans of the fetus and of the newborn infant they say that such may be found "in the presence or in the absence of abnormal sugar metabolism in the mother and in the presence, or in the absence, of abnormal sugar metabolism in the infant itself." Benner, in 1941, reports a case of a newborn of a diabetic mother, dying 24 hours after birth, who showed a tremendous increase in the number and size of islets and morphologic evidence of gonadotropic stimulation.

Another observation is that of John (1931)—an insulin-treated case of diabetes, with complicating hyperthyroidism and cirrhosis of the liver, car-

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cinoma of the liver and gallbladder, and interstitial pancreatitis. Insulin was discontinued and the patient was readmitted in coma, with a blood sugar of 30 mg per cent. Autopsy showed both atrophy and hypertrophy of islets, but the other pathologic findings make it impossible to be sure that the hypoglycemia antemortem was due to hyperinsulinism.

In 1924, Nuboer reported finding hypertrophy, islets 300–400 μ in diameter, both with and without diabetes, and suggested that most of the reported adenomas might not be true neoplasms but rather hypertrophy. The cases of adenoma reported up to that time had been those of Nicholls (1902) one case, Reitman (1905) one case, Herxheimer (1906), who found two in a case of diabetes, Moise (1908) two cases, and one case each by Helmholtz (1907), Cecil (1911), Heiberg (1911), Alezais and Peyron (1911), Rollett (1912), Lecomte (1913), and Koch (1914). Priesel (1922) reported three cases, and Schneider (1924) two cases. In 1926, Warren reviewed these and added four of his own. He included as the twentieth case the report by Lang (1925), which is the first recorded case of nodular hyperplasia of the islets, called by the author "adenomatosis." The patient, a female, age 39, gave a history of attacks of depression, headache, abdominal pain and vomiting, occurring at intervals. No blood sugar determinations were recorded. At operation, a "tumor mass" involving the tail and most of the body of the pancreas was found, and a palliative gastro-enterostomy was performed. The patient died of bronchopneumonia and the islet adenomatosis was observed at autopsy, together with cholelithiasis, another finding possibly related to the clinical symptoms. The pancreas showed countless yellow nodules, varying from 50–5,000 μ in diameter. These were encapsulated. There were no metastases. In none of the cases reported up to 1925, including this first case of adenomatosis, was there any definite clinical suggestion of hypersecretion.

In 1926, Herxheimer produced the first experimental hyperinsulinism by ligation of the pancreatic duct in a chicken. The result was hyperplasia of islets and an increase in the insulin content up to five or six times normal. The chicken died of hypoglycemia. Then came the first clinical case of hyperinsulinism with islet cell tumor (Wilder, Allan, Powell, and Robertson, 1927) which it will be recalled, had multiple nodules of infiltrating growth in the pancreas and metastases in liver, lymph nodes and mesentery, with a high insulin assay in the liver nodules.

In a second publication (Friantz, 1940) we have tabulated the cases with hyperinsulinism and tumor, benign and malignant, found at operation and at autopsy. In the literature since, there are records of additional cases. There are also four cases which we overlooked—three benign tumors which were cited by Cheley, Engel and Nesselrode in the discussion of a paper by Thomason (1934), and one case of carcinoma with metastases, Jacobsen (1934). The statistics which follow are, therefore, corrected to include these.

In addition to these omissions and the cases which have appeared in the

literature since our 1940 review, we have 16 more cases in our own series explored for supposed hyperinsulinism. Of these one (Case 18) was a carcinoma, proved at autopsy at another hospital. Ballinger (1940) interpreted this as an islet cell carcinoma arising in aberrant pancreatic tissue in the liver. We are inclined to doubt this interpretation. At operation in this hospital, a mass was found in the retroperitoneal area between the upper border of the head of the pancreas and the Spiegelian lobe of the liver. It was a very large tumor, measuring 10 x 6 x 6 cm. Its upper limits appeared to infiltrate the liver, and the lower limits did not appear to be continuous with the pancreas. This we now feel should be regarded as a carcinoma arising in aberrant pancreatic tissue, behind and above the head of the pancreas where such aberrant structures have been described. In the detailed study by Faust and Mudgett (1940) of 370 cases of aberrant pancreatic tissue, none was found in the liver.

In five other cases of the 16 in our new series explored for hypoglycemia no tumor was found. One was a case of von Gierke's disease, so demonstrated at postmortem examination. In one case no tissue was removed. Eighteen months after operation this patient continues to hold the slight improvement she showed immediately, which is difficult to explain. She needs her meals, otherwise she has symptoms, but her fasting blood sugar has risen from 44 to 79 mg per cent. In the remaining three, partial pancreatectomy was performed. In one of these, a girl of seven, half of the pancreas was resected. This showed, if anything, *hypoplasia* of islet tissue. She had no more convulsions after operation, but fasting blood sugar rose only from 42 to 56 mg per cent. She was then lost to follow-up. The next case in which no tumor was found had a partial pancreatectomy. There was marked hyperplasia of islets but no neoplasia, and the patient was unimproved. He committed suicide three months after operation. The last case without tumor in Doctor Whipple's personal series (with operation, however, performed not at Presbyterian Hospital but at St. Luke's Hospital, New York City) had a partial pancreatectomy, without relief of symptoms. The pancreas showed nothing unusual.

In our series reported in 1940, 16 cases had been explored for hypoglycemia, in only one of which (Case 22) no tumor was found. Subsequent to the time the report was submitted for publication, this patient was re-explored (May, 1940) because of persisting symptoms. At the second procedure a tumor 1.7 cm in diameter was found situated in the head of the pancreas, and was removed, with relief of symptoms.

Our series, therefore, now comprises 32 cases in all, in 27 of which tumor was found—one irremediable carcinoma and 26 operable cases. Four of these were reported in 1940 as having certain histologic characteristics suggestive of malignant tumor. Four more of the recent cases also show blood vessel invasion, making eight of the 26 under suspicion histologically. One of these, previously reported, was a postoperative death. The other seven are all

symptom-free, the earliest, and, incidentally, the one most characteristic of carcinoma histologically, being now a six-year arrest, and two others having gone more than five and four years, respectively, without return of symptoms

Before completing the list of published cases to date, with our own added, we wish to present in some detail the histories of our own two cases of *adenomatosis*. Presumably, in both of these cases the same hyperplasia and neoplasia were present in the tissue left behind at partial pancreatectomy, and yet, to date, there has been no return of symptoms in either patient. The second case is very recent (only six months after operation) but as the first now has had no symptoms for 16 months, in spite of carrying heavy work in a war industry, it seems fair to report them both as similar*.

Case 25—Dr Allen O Whipple S G, female, age 46, white, English. The patient was referred because of persisting symptoms following two operations. For five years before her admission to St Luke's Hospital, in New Bedford, Mass., she had had spells of weakness and fainting, worse at the time of the menstrual period. These were somewhat relieved by benzedrin sulfate, and the patient herself noticed that candy would abort or shorten an attack. Administration of orange juice was observed to relieve an episode of semiconsciousness. At this time, the patient was moderately obese, weight 163 pounds. The rest of the physical examination was essentially negative. The fasting blood sugar 12/24/41, was 23 mg per cent. There were no other significant laboratory findings.

Operation—February 24, 1942. Dr Milton T MacDonald, St Luke's Hospital, New Bedford, Mass. Excision of adenoma of pancreas. This measured about 0.5 cm., and was found near the tail of the pancreas at its upper border.

Postoperative Course—The patient felt somewhat improved for a few weeks and then began to manifest her old symptoms. Blood sugars were found as low as 40 mg per cent.

Second Operation—May, 1942. Dr Milton T MacDonald, St Luke's Hospital, New Bedford, Mass. At this procedure a 0.75-cm tumor was removed from the anterior surface of the pancreas, just below the superior border.

Second Postoperative Course—The patient again improved for a short time but blood sugars remained between 40 and 50 mg per cent.

On admission to the Presbyterian Hospital, New York City, July 7, 1942, her weight was 165 pounds. Fasting blood sugar taken the next morning, with the patient found in shock at 6:30 A.M., was 34 mg per cent.

Third Operation—July 10, 1942. Dr Allen O Whipple. The abdomen was explored through a right rectus incision. The duodenum was mobilized for satisfactory palpation of the head of the pancreas. No tumor could be felt or seen. A partial pancreatectomy was, therefore, performed, with the removal of tail, body and a portion of the head.

Third Postoperative Course—The patient made a good recovery, and had no return of symptoms 16 months after operation, in spite of heavy work on a milling machine, 48 hours a week. On her last follow-up examination, in November, 1943, her fasting blood sugar was found to be 90 mg per cent, and her glucose tolerance test showed

* In connection with these two cases attention is called to the review by David, in 1940, of the results of pancreatectomy in hypoglycemia. We will not repeat these figures. A few other cases with operation *without tumor* may be added: Barnes and Richmond, 1935; Berry, 1935; Boone, 1934; Eagleston and Berkenbilt (Case 2) 1942; Fanta, 1937 (aberrant pancreas); Guerry and McCutcheon, 1936; Harris 1938; Holman, Wood and Stockton (Case 4) 1943; Magner (Case 2) 1941; Quarrier and Bingham (Case 3) 1942; Reed, 1934; Rynearson and Walters, 1938; Smith, F G, 1942 (aberrant); Wechsler and Garlock (Case 2) 1944, and Winans, 1933.



FIG 1—Case 1 Photomicrograph showing topography. Normal, hyperplastic and neoplastic islets ranging from 0.14 Mm in greatest diameter

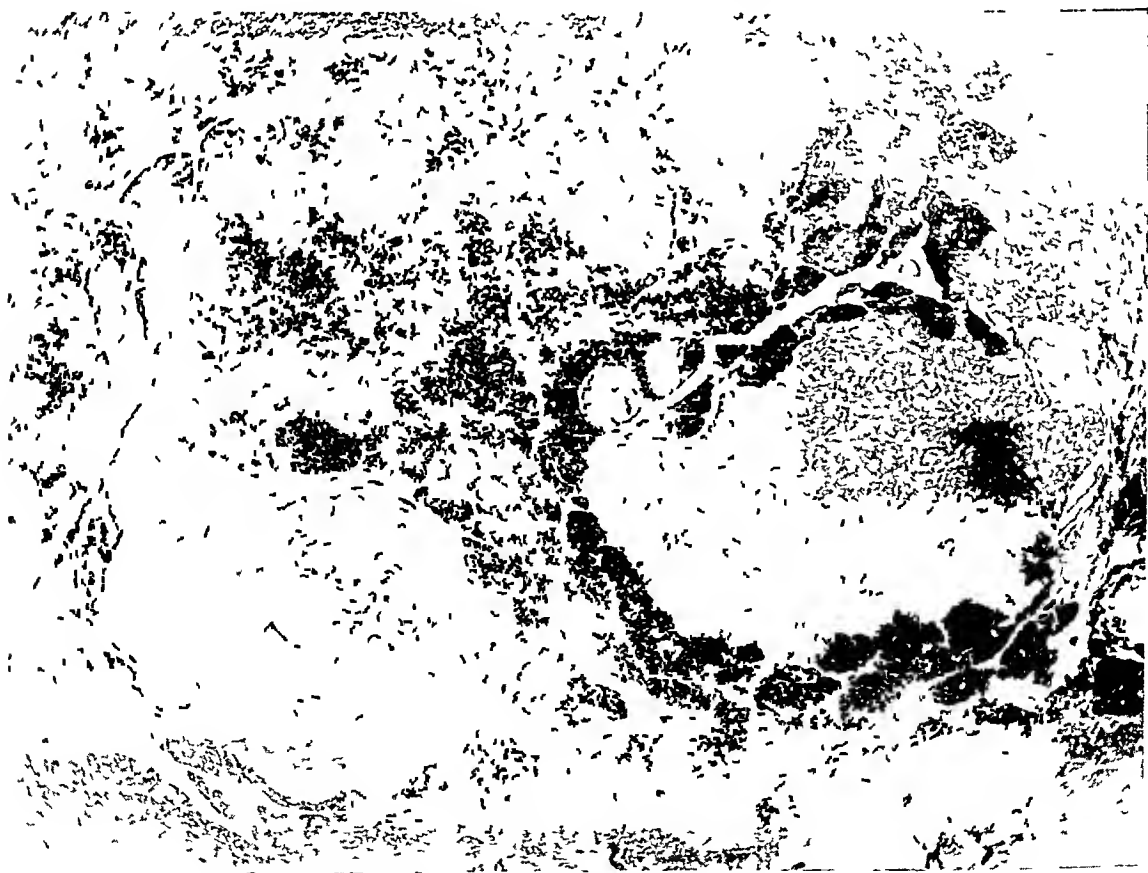


FIG 1—Case 2 Comparable field to Case 1. Islet diameters ranging from 0.14-2.4 Mm

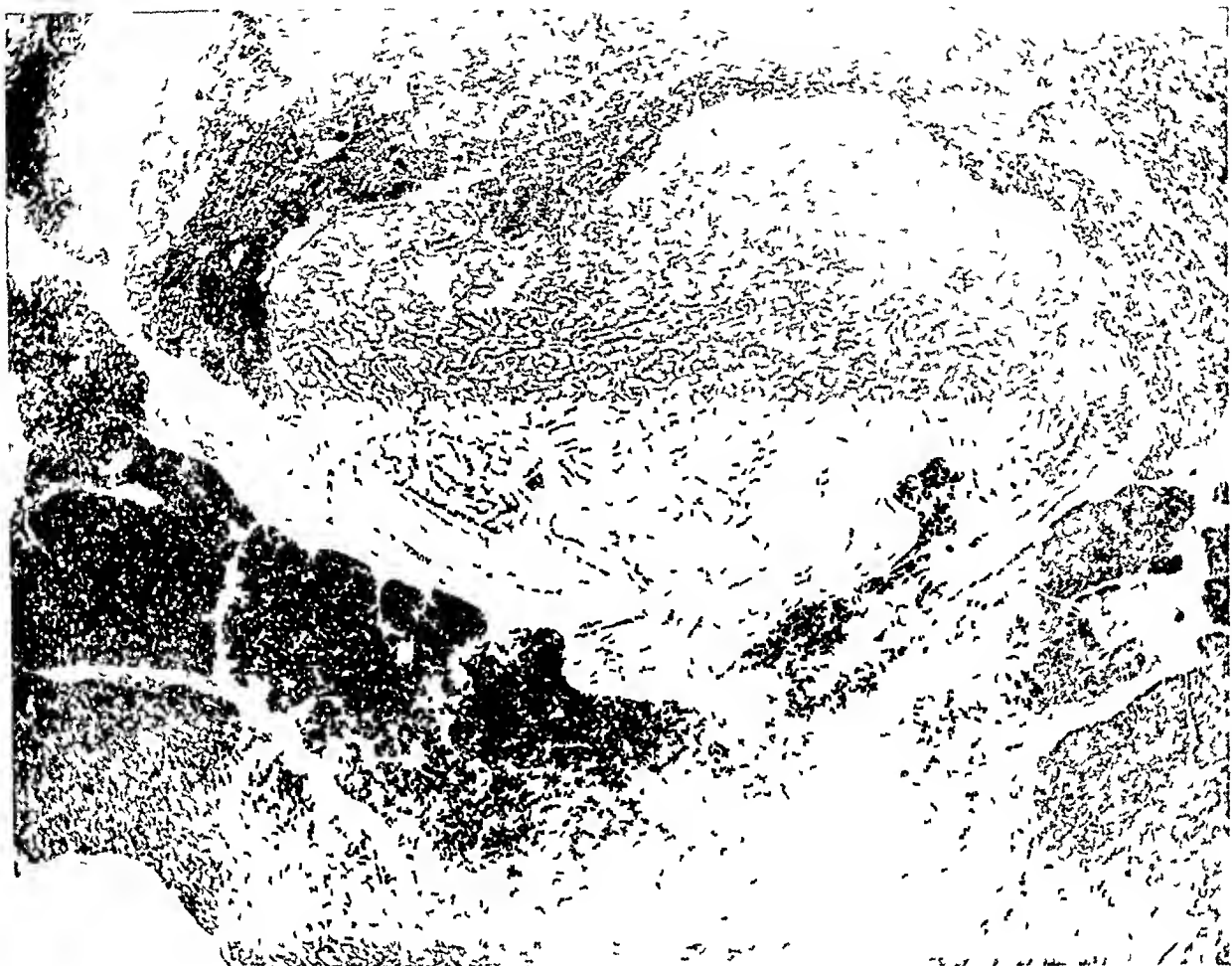


FIG 2—Case 2 Comparable field to Case 1 Macroscopic islet 4.0 Mm in diameter

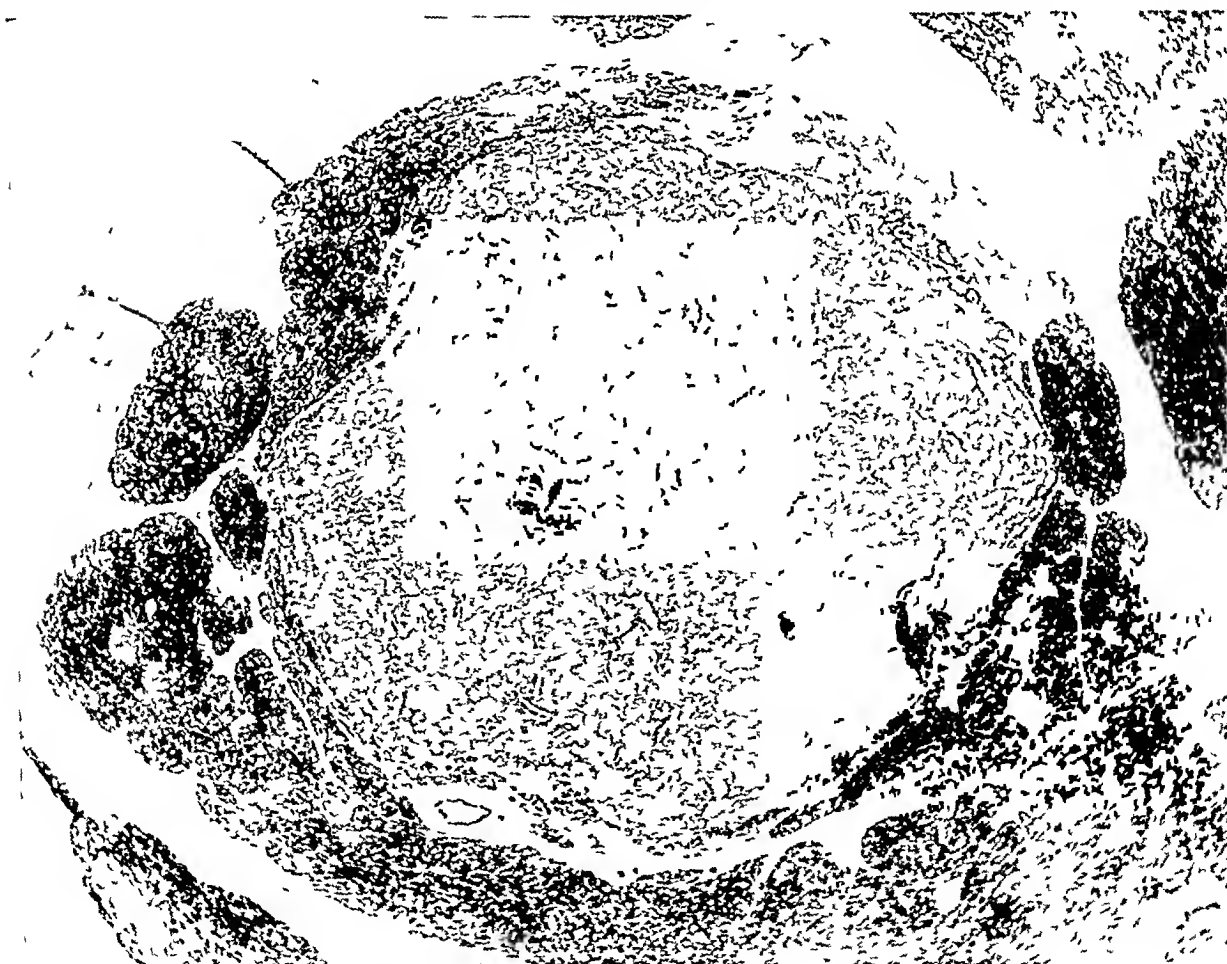


FIG 2—Case 1 Photomicrograph showing neoplastic islet 3.7 Mm in greatest diameter

figures all on the high side, with a diabetic type of curve. The patient had gained ten pounds and was advised to follow a 1200-caloric diet. She had not reported untoward symptoms since.

Pathologic Examination—Gross S P No 82635. The specimen consisted of a segment of pancreas measuring 6.5 x 3 x 0.7 cm, and weighing, fresh, 8 Gm. A number of small purple or violet areas were seen on section, which were slightly raised above the surrounding yellow pancreatic tissue. These were considered as possible multiple adenomata when seen in the fresh state. They were discrete, but showed no striking capsule grossly.

After paraffin section, five discrete adenomata could be seen with the naked eye in hemotoxylin and eosin preparations on the slide. These measured 7, 5, 3, 3, and 2 Mm, respectively.

Microscopically, the sections showed adenomata of the ribbon type, similar to those described by Dr I M Mason, Pathologist, St Luke's Hosp, New Bedford, Mass., and were composed of islet cells, intimately associated with vascular spaces, some of which showed no endothelial lining. The adenomata were sharply demarcated, but not completely encapsulated. No mitotic figures were seen and no blood vessel invasion was recognized. In addition to these five macroscopic foci, there were many microscopic foci which were similar histologically, and, also, there were an unusually large number of normal and hyperplastic islets. Transitions were seen between these and the adenomata. In some of the small foci it was impossible to decide whether they should be considered hyperplasias or true neoplasms (See photomicrographs).

Case 30—Dr Allen O Whipple O T V, female, age 46, white, American. The patient came to Vanderbilt Clinic, June 1, 1943, complaining of fainting spells of two years duration. These came on usually in the morning and lasted two to six hours. Return to consciousness was followed by severe headache and muscle pain. There was twitching occasionally during attacks and once she bit her tongue.

Physical examination was essentially negative except for cataract O D. The condition, thought to be epilepsy, was not relieved by dilantin and phenobarbital. On a clinic visit, September 2, 1943, she volunteered the information that eating sugar helped her, and she was then admitted to the Neurological Institute for study.

At this time, she gave additional history of great irregularity in menstrual periods, a gain in weight of 90 pounds (130-220) since the birth of a child six and one-half years before, with gain most marked during the two years previous to admission, when fondness for sweets became more marked and when they were needed to ward off attacks.

Physical Examination. Height 5 feet 5.5 inches, weight 220 lbs. Except for this obesity there was nothing significant.

Laboratory Data. The serum cholesterol was 252 mg per cent, and basal metabolic rates -7. The lowest fasting blood sugar was 41 mg per cent. A roentgenogram of the skull showed no change in the sella turcica. Electro-encephalograms, interpreted by Dr Paul Hoefer, showed high voltage, slow activity of irregular pattern while the patient was fasting, and a completely normal pattern within one minute after injection of dextrose during hyperventilation. Five examinations were made in all, and it was the impression that there was a striking relation between electro-encephalogram, clinical picture, and food intake.

Blood sugar during an attack was recorded as 37 mg per cent. The patient was unconscious. She regained consciousness within two minutes after intravenous administration of 50 cc of 50 per cent glucose. Attacks occurred almost daily in spite of diet, and often required intravenous glucose for relief. Operation was, therefore, advised, and she was transferred to the Presbyterian Hospital.

Operation—October 19, 1942. Dr Fordyce B St John and Dr Allen O Whipple. The abdomen was explored through a long, curved transverse incision. The pancreas was small. There was a hard nodule palpable in the tail which was thought to be

ADENOMATOSIS OF ISLET CELLS

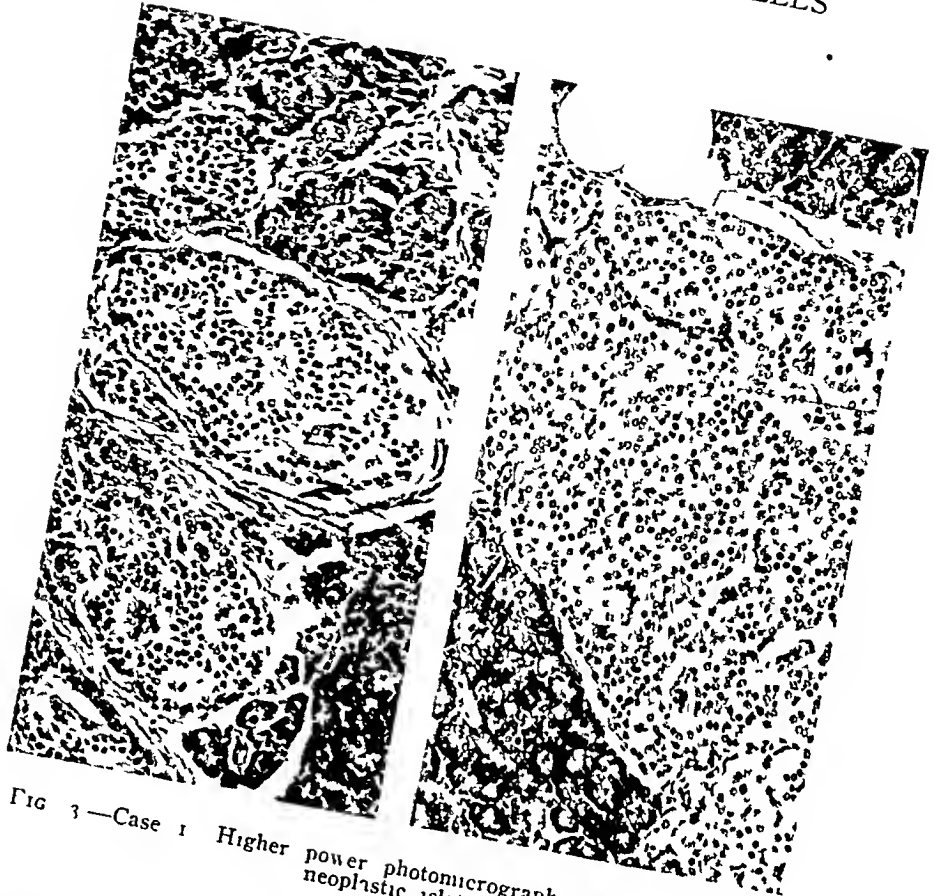


FIG 3—Case 1 Higher power photomicrographs showing detail of neoplastic islets

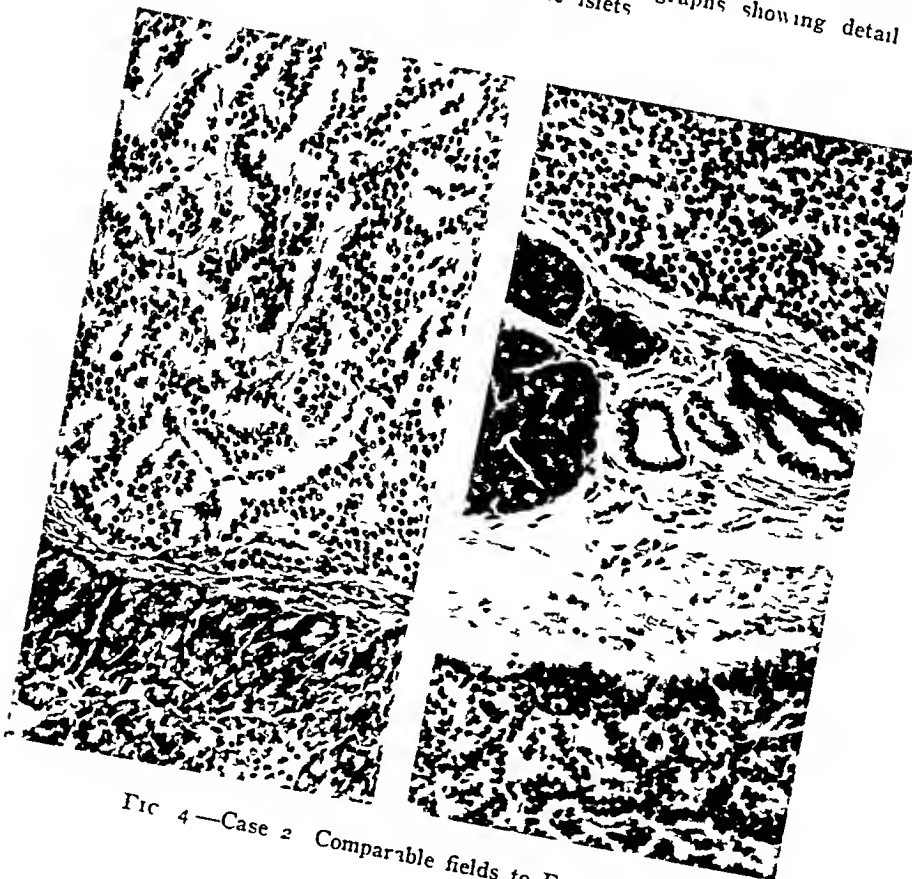


FIG 4—Case 2 Comparable fields to Figure 3

tumor, but satisfactory palpation was difficult because of the patient's obesity. The tail and part of the body were resected. Stubborn bleeding was encountered deep in the left upper quadrant which was controlled by the application of two long, curved clamps, left *in situ*, together with a cigarette drain.

Postoperative Course The clamps were removed on the seventh postoperative day. The sinus was closed at the end of the fifth week. The patient was discharged on the 47th postoperative day, and the wound was healed in eight weeks.

Subsequent Course She came for follow-up examination three months after operation, at which time her blood sugar, not fasting, was 103 mg per cent. Previous fasting blood sugars in the hospital had been as low as 68 mg per cent on the 46th postoperative day. The patient, however, was on a reducing diet which she continued after leaving the hospital. Six months after operation, April 18, 1944, she again reported at the Follow-up Clinic, free of symptoms of hypoglycemia.

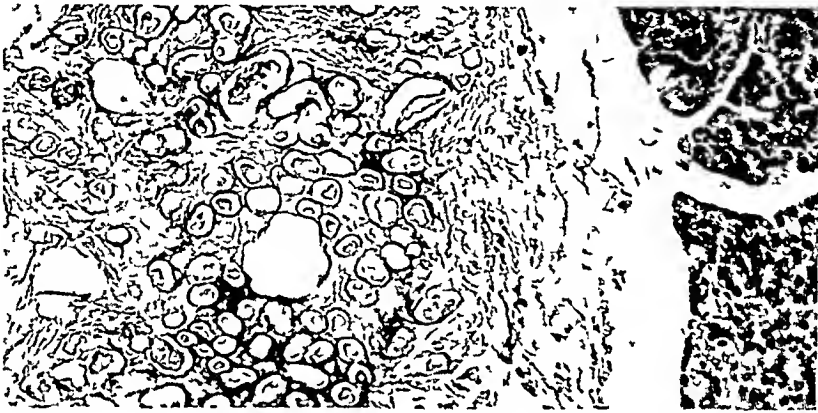


FIG 5—Case 2 Typical calcified nodule

Pathologic Examination—Gross S P No 87322 The specimen consisted of a segment of pancreas measuring 5 x 4 x 3 cm, and weighing, fresh, 13 Gm. Attached to the splenic end there was some fat in which there were numerous calcified nodules, 1–2 Mm in diameter. On section of the pancreas two circumscribed, nonencapsulated, soft, red areas, each about 5 Mm in diameter, were found. Scattered throughout the rest of the pancreas there were tiny, translucent red areas similar to the two larger ones, and the lesion, after frozen-section at the time of operation, was interpreted as adenomatosis.

Microscopically, on examination of paraffin preparations, this impression was confirmed. Hypertrophy and hyperplasia of islets was seen, and ribbon-like arrangements of islet cells with finger-like extrusions into the adjacent pancreatic tissues. These were typical adenomata. Multiple microscopic areas of calcification were found, interpreted, after considerable study, as calcification of multiple adenomata. The gross calcified masses adjacent to the tail showed tiny remnants of pancreatic tissue also, and were interpreted as larger calcified tumors. (See photomicrographs)

This brings us to the statistical summary of the cases *with tumor*, as we have been able to find them to date (Table I).

In discussing carcinoma of islet cells attention must be drawn to a general article by Duff and Murray (1942), and an excellent review by Hanno and Banks (1943). We have emphasized before the difficulty of being sure of the histogenesis of tumors in which no hypoglycemia is noted. In the

ADENOMATOSIS OF ISLET CELLS

TABLE I
HYPOGLYCEMIA—ISLET CELL TUMORS IN WHICH METASTASES WERE FOUND—FIFTEEN CASES

Author	Date	Sex	Age	Min Bld Sugar Mg %	Operation	Biopsy of liver	Biopsy of pancreas	Biopsy of metastasis in liver	Single or Multiple	Result	Metastases in
1 Wilder, Allan, Power and Robertson	1927	M	40	25	Cholecystectomy	Biopsy of liver	Biopsy of pancreas	Biopsy of metastasis in liver	Single	Died one month	Metastases in liver
2 Judd, Faust and Dixon	1934	F	18	45	Biopsy of metastasis in liver	Biopsy of pancreas	Biopsy of metastasis in liver	Biopsy of metastasis in liver	Multiple	Died four weeks	Metastases in liver
3 Jacobsen	1934	M	36	25	Biopsy of metastasis in liver	Biopsy of pancreas	Biopsy of metastasis in liver	Biopsy of metastasis in liver	Single	Hemorrhage from duodenum	Metastases in liver
4 Bickel, Mozer and Junet	1935	M	56	Originally diabetic	None	Biopsy of metastasis in liver	Biopsy of pancreas	Biopsy of metastasis in liver	Single	Autopsy	Metastases in liver
5 Cragg, Power and Lindem	1937	F	41	Bld sugar dropped 325—8	30	Biopsy of metastasis in liver	Biopsy of pancreas	Biopsy of metastasis in liver	Single	Died four months	Metastases in liver
6 Joachim and Banowitz	1938	F	31	30	Resection of spleen and portion of tumor in tail of pancreas and a lymph node showing metastasis	Exploratory	Exploratory	Exploratory	Multiple (diffuse through pancreas)	Postoperative death	Metastases in liver, peritoneum and epididymus
7 Seckel*	1939	M	36	16	Exploratory	Exploratory	Exploratory	Exploratory	Multiple	Died five months	Metastases in liver and lymph nodes
8 Ilini, Betty Hemsath	1941	F	45	29	None	None	None	None	Single	Postoperative death	Metastases in liver and lymph nodes
9 Ballinger (Whipple—Case 18)	1941	M	53	30	Biopsy	Tumor of aberrant pancreas	Biopsy	Biopsy	Single	Died ten weeks postoper	Metastases in liver one adrenal spine, lungs pleura retroperitoneal and mediastinal nodes
10 Quarrier and Hughlin (Case 1)	1942	M	73	21	None	None	None	None	Single	Autopsy	Metastases in regional nodes and mediastinal nodes
11 Grist	1942	F	48	27	Evison	Tumor in tail	Biopsy of liver metastases	Biopsy of tumor in tail of pancreas and of metastasis in liver	Single	Died four months postoper	Extension to liver
12 Himm and Banks	1943	M	68	21	Biopsy of liver metastases	Biopsy of tumor in tail of pancreas and of metastasis in liver	Biopsy of metastases in liver	Biopsy of metastases in liver	Single	Montefiore Hospital Autopsy	Metastases in retroperitoneal nodes mesentery lung adrenals heart vena cava spleen and subcutaneous tissue of clavicular region
13 Holman Wood and Stockton (Case 3)	1943	M	45	27	Biopsy of liver metastases	Biopsy of tumor in tail of pancreas and of metastasis in liver	Biopsy of metastases in liver	Biopsy of metastases in liver	Single	Died six weeks	Metastases in liver and regional lymph nodes
14 Browning	1943	M	36	12	Biopsy of metastases in liver	Biopsy of metastases in liver	Biopsy of metastases in liver	Biopsy of metastases in liver	Single	Died two days	Metastases in liver
15 Brunschwig Allen Owens and Thornton	1944	M	32	14	1 Sept 39	Excis 2 tumors and tail	Excis large tumor of body (Liver metastases present)	Excis of most of head (Liver metastases present)	Multiple	Died two hours after last operation	Marked basophilism

*Reported also by Brunschwig, Gomori, and Cannon (cited by Gray)

22 cases listed by Hanno and Banks one case is included erroneously (Lloyd) This leaves 21 cases which may be interpreted as malignant In seven there were no clinical data to establish the diagnosis of hyperinsulinism (Fabozzi (1903), four cases quoted, considered by many doubtful as to islet cell origin, Zanetti (1927), one case, Hamdi (1932), one case, Evangelisti (1935), one case) In three cases reported by Duff and Murray (1942) hypoglycemia was known to be absent, and the remaining 11 cases, *i e*, 11 of 21, were cases of hyperinsulinism, roughly one-half the cases Our own table lists only 15 cases of carcinoma These were all cases with hypoglycemia, with metastases, and they include all of the cases of Hanno and Banks in which hypoglycemia was known to be present *

We have had two cases *without* hypoglycemia, which we have interpreted as islet cell carcinomas † One was a man, age 69, with extensive liver metastases, found at operation The pancreas at autopsy proved to be the primary site of tumor, almost six years after the operation, which demonstrated metastatic disease, a longer history than any of the cases *with* hypoglycemia and metastatic disease The other case is a woman, age 53, who underwent resection of the body and head of the pancreas together with pylorus and duodenum She has shown no evidence of recurrence to date, four years after operation, and no hypoglycemia

The cases of hyperinsulinism with islet cell tumor considered benign, removed at operation, we listed in 1940 in Table II Forty-six cases were listed, one incorrectly, Mathias (see footnote) Of the 45 cases correctly listed five had more than one tumor, Graham and Womack (1933), two tumors, Whipple and Frantz, Case 3 (1935), two tumors, Whipple and Frantz, Case 4 (1935), two tumors, Kalbfleisch, Case 3—Heupke and Obert (1937), five tumors, Frantz, Case 9—Whipple (1940), two tumors To Table II must be added 31 cases as follows

The cases of hyperinsulinism with islet cell tumor considered benign found at autopsy we listed in 1940 in Table III Twenty-four cases were listed, of which three had more than one tumor (Terbruggen, Case 1—Frank (1931), multiple, Wolf, Hare, and Riggs (1933), three tumors, Frank, Case 2, (1931), two tumors) To Table III must be added six cases as follows

The cases of hyperinsulinism with islet cell tumor suspected of being malignant, removed at operation, we listed in 1940 in Table IV Nineteen cases were listed, of which three had more than one tumor (Judd, Allan, Frank and Rynearson (1933), two tumors, Ziskind and Bayley (1937), two

* There is a sixteenth case of hyperinsulinism, with metastatic islet cell carcinoma, reported by Slye and Wells (1935) but the patient was a dog

† The difficulties of interpretation are well illustrated by a case with multiple metastases reported by Willis (1936), in which the author is uncertain of the origin, and also by the case of Mathias (1928), which has been repeatedly misquoted, and is wrongly listed in our own report in 1935, where it should appear in Table VII instead of Table III, and again in 1940 where it should not appear in Table II as there was no recorded hypoglycemia

TABLE II (1940)—Continued

(Ref Annals of Surgery, 112, No 2, 167-168, August, 1940)
 HYPOGLYCEMIA—ISLET CELL TUMORS REMOVED AT OPERATION
 CONSIDERED TO BE BENIGN TOTAL CASES—SEVENTY-SIX
 MULTIPLE TUMORS—FLEVEN

	Author	Date	Single or Multiple
46	Cheley	1934	Single
47	Engel	1934	Single
48	Nesselrode	1934	Single
49	Duncan Hayward and Fleck (Case 1)	1939	Single
50	Windfild (Case 1)	1940	Single
51	Windfild (Case 2)	1940	2 tumors
52	Windfild (Case 3)	1940	Single
53	Greenlee, Lloyd Bruecken and McEllroy	1940	Single (Hyperthyroidism*)
54	Burtress Koehler, and Saint	1941	Single
55	Magner (Case 1)	1941	Single
56	Meyer Antman and Perlman	1941	Single
57	Rudd and Walton	1941	Single (aberrant†)
58	Brown	1942	Single
59	Stem	1942	Single
60	Romano and Coon	1942	Single
61	Erb Dillon, and Ferguson	1942	Single
62	Thomas	1943	Single (aberrant†)
63	Ceballos and Rosenblatt	1943	Single
64	Spangler	1943	Multiple
65	Holman, Wood and Stockton (Case 1)	1943	2 tumors (1 aberrant†) Hypertrophy of islets
66	Rayner, Rogerson and Jones	1943	Multiple
67	Wechsler and Garlock (Case 1)	1944	Single
68	Cole	1944	Single
69	Priestley, Comfort, and Radcliffe	1944	Single (Total pancreatec- tomy†)
70	Whipple (Case 11) Not published	1944	Single (reoperation)
71	Whipple (Case 16) Not published	1944	Single
72	Whipple (Case 25) Not published	1944	Adenomatosis
73	Whipple (Case 26) Not published	1944	Single
74	Whipple (Case 27) Not published	1944	Single
75	St John and Whipple (Case 30) Not published	1944	Adenomatosis
76	Whipple (Case 31) Not published	1944	Single

*The association of thyroid pathology with hypoglycemia has been discussed by John (1931), Aitken (1936), Womack and Cole (1937), and Greenlee, Lloyd and Bruecken (1940)

†Islet cell tumors of aberrant pancreas have been reported by Vecchi (1914) Stewart and Hartfall (1928) White and Gildea (1937) Rudd and Walton (1941) Ballinger (Whipple—Case 18) (1941) Thomas (1943) and Holman Wood, and Stockton (1943)

Excision of aberrant pancreatic tissue not tumor, has been reported by Smith Frederick G (1942) and Fanta (1937) both with relief of symptoms Possible sites of aberrant pancreatic tissue are shown by Faust and Mudgett (1940) in a review of 370 reported cases and Thorsness (1940)

‡The only other total pancreatectomy recorded is that of Rockey (1943) which was done for carcinoma not islet cell Survival in this case was only 15 days In the case of Priestley, Comfort, and Radcliffe (1944), survival has been 16 months, and the resultant diabetes is mild

TABLE III—Continued

(Ref ANNALS OF SURGERY 112 No 2 169 August 1940)

HYPOGLYCEMIA—ISLET CELL TUMORS FOUND AT AUTOPSY

CONSIDERED TO BE BENIGN TOTAL CASES—THIRTY

MULTIPLE TUMORS—THREE

	Author	Date	Single or Multiple
25	Duncan Hayward and Fleck (Case 2)	1939	Single
26	Heyn and Somnier	1940	Single
27	Kerwin	1942	Multiple
28	Quarrier and Bingham (Case 3)	1942	Single
29	Stevenson and Rannie	1942	Single
30	Holman Wood and Stockton (Case 2)	1943	Single (aberrant)

TABLE IV—Continued

(Ref ANNALS OF SURGERY 112 No 2 170 August 1940)

HYPOGLYCEMIA—ISLET CELL TUMORS REMOVED AT OPERATION

SUSPECTED OF BEING MALIGNANT TOTAL CASES—TWENTY-SIX

MULTIPLE TUMORS—FOUR

	Author	Date	Single or Multiple
20	Forbes Davidson and Duncan	1939	Single
21	Quarrier and Bingham (Case 1)	1942	Single
22	Quarrier and Bingham (Case 4)	1942	Multiple
23	Whipple (Case 20) Not published	1944	Single
24	Whipple (Case 22) Not published	1944	Single
25	Whipple (Case 23) Not published	1944	Single
26	Whipple (Case 29) Not published	1944	Single

TABLE V—Continued

(Ref ANNALS OF SURGERY 112 No 2 171 August 1940)

HYPOGLYCEMIA—ISLET CELL TUMORS FOUND AT AUTOPSY

SUSPECTED OF BEING MALIGNANT TOTAL CASES—TWO (NO NEW CASES)

MULTIPLE TUMORS—NONE

tumors, J Smith (1939), multiple) To Table IV must be added seven cases as follows

Two cases of hypoglycemia with islet cell tumors suspected of being malignant, found at autopsy listed in 1940 in Table V Both were single We have found no new cases of this sort reported at autopsy since then

It will be noted that of tumors considered benign 14.2 per cent were multiple, of suspicious tumors, 14.3 per cent, and of tumors of proven malignancy, 20 per cent We must emphasize again that in the group of suspicious tumors *the suspicion, of the pathologist not the surgeon, has yet to be confirmed in a single case by follow-up data*

To the cases of multiple tumor and of true adenomatosis there must be added for completeness those cases with hypoglycemia in which, in the pathologist's opinion, although there was no true neoplasia, there was hypertrophy and hyperplasia There are 11 such cases, and Table VI, therefore, is an analysis of the whole group

Summarized, all of the foregoing figures give us totals seen in Table VII

TABLE VII
SUMMARY OF STATISTICS

	Single	Multiple	Total	Per Cent Multiple
Tumors removed at operation and considered benign	65	11	76	
Tumors found at autopsy and considered benign	26	4	30	
Total benign tumors	91	15	106	14.2
Tumors removed at operation and suspected malignant	22	4	26	
Tumors found at autopsy and suspected malignant	2	0	2	
Total suspicious tumors	24	4	28	14.3
Total cases of tumor <i>without proven malignancy</i>	115	19	134	14.2
Carcinoma with metastases <i>proven malignancy</i>	12	3	15	20.0
TOTAL CASES OF TRUE NEOPLASM	127	22	149	14.8
HYPERTROPHY AND HYPERPLASIA WITHOUT NEOPLASM			11	

SUMMARY

The review of published cases and those in our own series, presented in 1940, is here extended to include the rest of the cases in the literature, as we have been able to find them, and the new cases in our own series

Two of our own cases are analysed in detail as they are the first in which a diagnosis of hyperinsulinism with adenomatosis has been made

CONCLUSIONS

Multicentric origin of benign and malignant tumors of islet cells is suggested by the pathologic findings in the cases reviewed

In the multicentric cases with hyperinsulinism there seems to be a good possibility that hyperplasia and neoplasia in the remaining pancreas may result in return of hypoglycemic symptoms

In the multicentric cases the possibility of malignant disease must be considered

Such cases should be followed for long periods in order to establish a basis for prognosis in others

TABLE VI
HYPOGLYCEMIA—HYPERTROPHY, HYPERPLASIA, MULTIPLE TUMORS AND ADENOMATOSIS

Author	Date	Sex	Min Bld Sugar		Operation or Autopsy	Pathology	Result
			Age	Mg %			
1 Massa	1929	M	67	58	Autopsy	Hypertrophy of islets Adenocarcinoma of pancreas with obstruction of ducts and metastases	Autopsy
2 Terbruggen	1931	F	30	23	Autopsy	Five tumors encapsulated, and many tiny ones Islets normal Adenomatosis?	Autopsy
3 Phillips	1931	M	56	25	Autopsy	Hypertrophy of islets	Autopsy
4 Graham and Womack	1933	M	22	25	1 Excis of tumor	1 Adenoma 1 x 0.8 cm	1 No improvement
					2 4 cm of tail excised	2 Adenoma 2 cm	2 Symptoms relieved Mental deterioration
5 Mosenthal and MacBrayer (Quoted by Wilder)	1933	M	39	50	Autopsy	Hypertrophy of islets	Autopsy
6 Wolf Hare, and Riggs	1933	M	10	54	Autopsy	Three tumors middle, tail, and head 1.0 3.0 3.0 cm	Autopsy
7 Judd, Allan Frank, and Rynearson (Case 7)	1933	M	32	40	Two tumors 1.5 cm and 2 cm, respectively	Carcinoma?	Symptom-free 23 months
8 Simon	1934	M	26	51	Resection 60 Gm	Hypertrophy of islets	Improved 2 months
9 Frank (Case 2)	1935	F	14	11	Autopsy	Two tumors, head and tail	Autopsy
10 Dannenberg Bell and Gouley	1935	M	3	71	Autopsy	Hypertrophy and hyperplasia of islets Fibrosis of pancreas	Autopsy
11 Whipple and Frantz (Case 3)	1935	M	28	38	1 Excis tumor junction body and tail	1 Adenoma	Symptom free Died duodenal hemorrhage 18 months
					2 Excis tumor tail	2 Adenoma	
12 Whipple and Frantz (Case 4)	1935	M	38	30	Excis tumors—1 cm in body, 0.6 cm in head	Adenomas	Symptom-free 105 months
13 McCaughan and Broun (Case 1)	1937	M	20	54	Resection of tail 8 Gm	Number of islets increased	Some improvement
14 McCaughan and Broun (Case 2)	1937	M	17	36	Resection — body and tail (22.5 Gm)	Hypertrophy of islets	No improvement
15 McCaughan and Broun (Case 6)	1937	F	24	70	Resection 35 Gm	Hypertrophy of islets	No improvement

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PANCREATICOJEJUNOSTOMY AND OTHER PROBLEMS ASSOCIATED WITH THE SURGICAL MANAGEMENT OF CARCINOMA INVOLVING THE HEAD OF THE PANCREAS

REPORT OF FIVE ADDITIONAL CASES OF RADICAL PANCREATICODUODENECTOMY

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It has become increasingly apparent during the past five years or so that surgical ailments have been increased to a point where carcinoma involving the head of the pancreas may be attacked radically. It is common knowledge that prior to 1935 sporadic attacks were made upon cancer in this region. The incidence of success, however, was so meager and the mortality so high that no operation contemplating eradication of the disease ever gained any degree of popularity. The most complete review of these early experiences may be found in Hunt's¹ review of the subject, appearing in 1941.

Largely due to the impetus given this problem by Whipple, Parsons and Mullins,² in 1935, and by Whipple,³ in 1938, the entire subject has been reopened and the number of successful attacks upon ampullary and peri-ampullary carcinomata have been increasing yearly.³⁻¹² In order to further the study of patients confronted with cancer in this region and to counter the all too generally held impression that its surgical attack is hopeless, the following seven cases are recorded. In general, these experiences parallel those reported from other institutions with regard to mortality, postoperative complications and the evolution of the operation as it is now commonly performed.

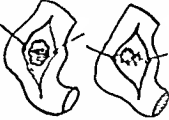
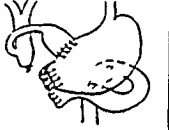


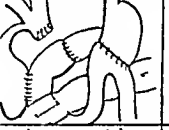


One of these cases (Case 4) has been previously reported⁹ but is included here for the sake of completeness. The significant features of each case are recorded in Table I, while more detailed clinical abstracts appear in the case reports.

In view of the fact that each of these cases demonstrates one or another of the significant phases in the evolution of this major surgical operation they may best be discussed under subject headings rather than as individual cases.

Diagnosis—One of the most difficult problems associated with the surgical management of these patients is the establishment at the operating table of a positive diagnosis of cancer. In this respect these tumors may be conveniently divided into two groups. Those in and about the ampulla of Vater, and those lying deeply in the head of the pancreas. The former usually offer no great difficulty save for the fact that upon frozen section of their more or less superficial portions these polypoid tumors may appear

benign under the microscope, where actually they are malignant. If, however, it is borne in mind that very few ampullary tumors are benign, it is obvious that unless their benignity can be clearly demonstrated, they should, if possible, be subjected to radical removal. Case 6 is an excellent example of this problem. Numerous frozen sections at the first operation all showed a benign tumor, and it was upon this assumption that local excision was per-

TABLE I
SIGNIFICANT FEATURES OF SIX CASES OF RADICAL PANCREATODUODENECTOMY

PATIENT NO AGE SEX	HISTORY AND PHYSICAL EXAMINATION	DIAGNOSIS	OPERATION	OPERATION DIAGRAMMED	PO COMPLICATIONS	FOLLOW-UP
CASE 1 R A NO 277074 57YRS M	ABDOMINAL DISTRESS 3 WKS JAUNDICE 2 WKS WT LOSS 10 LBS P E JAUNDICED	CARCINOMA OF AMPULLA OF VATER	1 GASTROENTEROSTOMY 2 CHOLECYSTOGASTROSTOMY 3 TRANSDUODENAL EXCISION 4 REIMPLANTATION OF COMMON AND PANCREATIC DUCTS		NONE	WELL 2 YRS RECURRENCE 3 YEARS 2
CASE 2 F B NO 27640 56YRS F	LOSS OF APPETITE 2 1/2 MRS MILD JAUNDICE 2 MOS DEEP JAUNDICE 1 WK NO WEIGHT LOSS P E NEGATIVE	CARCINOMA OF AMPULLA OF VATER	1 DUODENOSTOMY GASTROENTEROSTOMY 2 LIGATION COMMON DUCT 3 CHOLECYSTOGASTROSTOMY 4 PANCREATODUODENECTOMY 5 ATTEMPTED CLOSURE DUODENAL STUMP 6 JEJUNOSTOMY		PERSISTENT COMPLETE DUODENAL FISTULA	P O DEATH
CASE 3 P D M NO 254422 52YRS M	PAINLESS PROGRESSIVE JAUNDICE 4 MOS WEIGHT LOSS 30 LBS P E LARGE PALPABLE GALLBLADDER	CARCINOMA OF PANCREAS	1 CHOLECYSTOGASTROSTOMY 2 GASTROENTEROSTOMY 3 PANCREATODUODENECTOMY 4 RESECTION OF FISTULOUS TRACT		PERSISTENT PANCREATIC FISTULA SEVERE STEATORRHEA	LIVED 8 MONTHS (NO POST-MORTEM)
CASE 4 J B NO 311583 57 YRS M PREVIOUSLY REPORTED	PAINLESS JAUNDICE 1 MON WEIGHT LOSS 20 LBS P E JAUNDICED	CARCINOMA OF DUODENUM	RADICAL PARTIAL PANCREATICTOMY DUODENECTOMY PANCREATICOJEJUNOSTOMY CHOLECYST JEJUNOSTOMY GASTROJEJUNOSTOMY		P O PNEUMONIA INTERMITTENT ATTACKS CHOLANGITIS	LIVED 14 MONTHS DIED OF CARCINOMATOSIS POST MORTEM
CASE 5 N M NO 361219 69YRS M	PAINLESS JAUNDICE 8 WKS WEIGHT LOSS 50 LBS P E JAUNDICED	CARCINOMA OF AMPULLA OF VATER	RADICAL PARTIAL PANCREATICTOMY DUODENECTOMY PANCREATICOJEJUNOSTOMY CHOLECYST JEJUNOSTOMY GASTROJEJUNOSTOMY		P O WOUND INFECTION	WELL 1 YEAR
CASE 6 S H NO 363096 55YRS F	PAINLESS JAUNDICE INTERMITTENT 3 WKS NO WEIGHT LOSS P E JAUNDICE	CARCINOMA OF AMPULLA OF VATER	1ST ADMISSION EXCISION AMPULLARY CARCINOMA 2ND ADMISSION 2 MOS LATER RADICAL PANCREATODUODENECTOMY PANCREATICOJEJUNOSTOMY CHOLEDOCHOGASTROSTOMY GASTROJEJUNOSTOMY		NONE	WELL 3 MONTHS
CASE 7 W M NO 375553 67YRS M	EPIDASTRIC FULNESS 2 MOS WEIGHT LOSS 20 LBS P E EPIDAST TUMOR	CARCINOMA OF STOMACH WITH EXTENSIONS TO HEAD OF PANCREAS	SUBTOTAL GASTRIC RESECTION PARTIAL PANCREATIC RESECTION DUODENECTOMY PANCREATICOJEJUNOSTOMY CHOLEDOCHOGASTROSTOMY GASTROJEJUNOSTOMY		NONE	WELL 2 MONTHS

formed. Following removal, however, a section from the base of the tumor was obviously malignant.

The second group, those primary in the head of the pancreas, may offer great difficulty in clearly establishing their malignant nature at the operating table. This, of course, is due to the fact that not infrequently these tumors have their origin deep in the gland itself and, as they grow, they continue

to be surrounded by a shell of pancreatic tissue. And it is only this normal tissue that is generally accessible for frozen section. Further confusion in this regard may also arise from the fact that since these lesions frequently obstruct one or more branches of the duct system of the pancreas, the gross and microscopic picture of chronic pancreatitis is presented. Because the most difficult differential diagnosis lies between this entity and carcinoma, the problems associated with the accurate diagnosis of these lesions can readily be appreciated. This dilemma has led Cattell¹⁰ to point out that frequently the decision as to whether or not to perform a radical operation must depend upon the surgeon's ability to make a diagnosis based upon the clinical and gross pathologic findings. This, of course, may, at best, be uncertain, and undoubtedly will mean that as more and more of these tumors are attacked surgically, some patients will undergo a radical procedure for chronic pancreatitis. At the moment, there is not apparent any exact solution of this problem. The most logical approach, however, would seem to be one of carefully weighing all the details of a given case, and proceeding upon what seems to be the most reasonable course.

In connection with this problem of diagnosis a related situation may be mentioned. In patients requiring common duct exploration in which an associated chronic pancreatitis is found, it may be wise to leave a small catheter in the common duct in order to obtain postoperative cholangiograms. If such roentgenologic studies demonstrate a persistent obstruction of the common duct not due to overlooked stones, a number of pancreatic carcinomata will undoubtedly be discovered sufficiently early to warrant re-exploration at a time when such a tumor may be amenable to radical extirpation.

Local Excision of Ampullary Tumors—Because local excision of small ampullary tumors, together with reimplantation of the common and pancreatic ducts, is a relatively innocuous procedure, the early literature upon this subject is replete with case reports of transduodenal excision of these carcinomata.

A critical review of 98 patients subjected to this operation, as compiled by Hunt,¹ reveals that the postoperative mortality was 27 per cent, and that but five patients were alive over four years. Three of these may be considered cured, as they were well five, nine, and 22 years after operation. These data indicate that local excision of these tumors may be expected to yield an occasional long-range cure, but that certainly the incidence is low.

In this series, there are two cases in point (Cases 1 and 6). In Case 1 there was an apparent cure for three years but at the present time the patient presents complaints suggestive of recurrence. Case 6 promptly recurred after local excision.

One- Versus Two-Stage Operation—Whipple's² original communication postulated a two-stage operation. The many disadvantages attendant upon this soon became evident. With the discovery of the ability to control the

bleeding tendency in jaundiced patients by means of vitamin K, one of the foremost reasons for the two-stage procedure became invalid, and, in 1940, Whipple¹¹ performed, for the first time, the operation of radical pancreaticoduodenectomy in one stage. Since then the operation of choice has been that of complete extirpation of the pancreatic head and duodenum at one sitting, reserving the two-stage procedure only for the poorest of operative risks.

Extent of Duodenum to Be Removed—One of the most dreaded complications of operative procedures involving the duodenum is that of fistula formation at the site of closure of the duodenal stump. Early in the history of the development of the two-stage operation only that portion of the duodenum adjacent to the head of the pancreas was removed. Because this may leave the blood supply of the remainder of the duodenum seriously impaired, it is considered necessary to remove all of this structure together with the upper few centimeters of the jejunum. Case 2 is one in which a persistent duodenal fistula, which defied closure, undoubtedly was the greatest single factor contributing to her death.

Cholecystenterostomy versus Choledocho-enterostomy—The problem whether to secure external drainage of the biliary tract by way of the gallbladder or the common duct has been much discussed. In the two-stage operation it would have been obviously disadvantageous to have obscured the operative field by some form of choledochojejunostomy, therefore, the gallbladder had of necessity to be used, the anastomosis usually being performed between this organ and the stomach. This, all too frequently, presented two untoward complications, early, that of a biliary fistula at the site of division of the common duct, late, of an ascending biliary tract infection. With the acceptance of the one-stage procedure the possibility of the development of both of these sequelae could be minimized by the performance of a choledochojejunostomy. Although the gallbladder was utilized in Cases 2, 3, 4 and 5 without the development of any immediate postoperative complication, troublesome attacks of acute cholangitis marred the result in Case 4. In Cases 6 and 7 the common duct was employed at the suggestion of Doctor Whipple (Discussion⁹). In neither of these cases has any untoward complication developed. In the future it will undoubtedly be the policy of this clinic to utilize the common duct whenever possible.

Management of the Pancreatic Stump—The best method of dealing with the pancreatic stump has proved a troublesome problem centering about two controversial points. First, whether or not the external pancreatic secretion is necessary for the maintenance of an adequate digestive process, particularly of fats. It is unquestioned that as yet, undetermined percentage of patients tolerate deprivation of their external pancreatic secretions reasonably well. There are a number, however, of which Case 3 is an example, who persistently suffer from a severe degree of steatorrhea following ligation of their pancreatic ducts. The significant single fact is that it cannot be forecast prior to operation to which group any given patient will ultimately

belong. It would seem apparent, therefore, that until further information is available the external pancreatic function should, if possible, be maintained.

The second difficulty lies in the fact that no matter how meticulously the pancreatic duct and stump are closed, there is the risk of the formation of a postoperative fistula. This undesirable, and oftentimes fatal, compli-

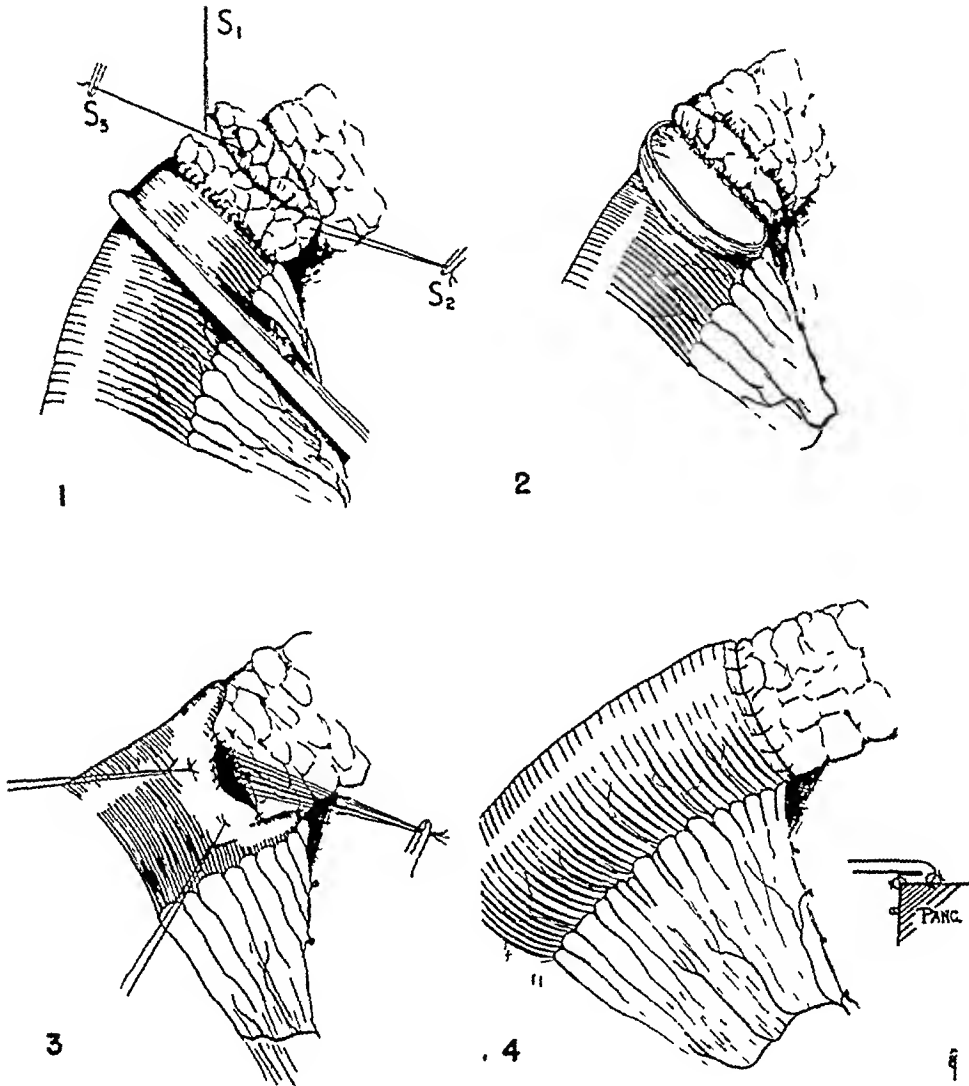


FIG 1—(1) First suture line in place, approximating the posterior aspect of the pancreas and the jejunal wall. (2) Second posterior suture line, approximating the posterior cut surfaces of the pancreas and jejunum. (3) First anterior suture line, placed but not completed. Just before these last few are tied, the ligature is removed from the pancreatic duct, permitting its immediate drainage into the jejunum. (4) Completed anastomosis. The inset demonstrates that the pancreatic stump is actually introduced into the inverted end of the jejunum.

cation may be avoided by a safe method of anastomosis between the intestinal tract and pancreatic stump. That such a satisfactory method is available seems apparent from examination of Cases 4, 5, 6 and 7, in which drainage of the external pancreatic secretions into the gastro-intestinal tract was secured by suture of the proximal end of the pancreas into the open end of the jejunum. The method by which this has been accomplished is outlined in some detail as follows:

Method of End-to-End Pancreaticojejunostomy—After completion of the radical removal of the duodenum and head of the pancreas, the proximal end of the jejunum is passed to the upper abdomen through a suitable rent in the mesocolon. As shown in Figure 1, the posterior aspect of the distal two centimeters of the pancreas is freed from the underlying tissues and held with its cut-surface upward by two suitably placed silk stay-sutures S 1 and S 2. Additional traction may be secured if necessary by means of S 3, the silk ligature placed upon the dilated pancreatic duct as it was divided earlier in the course of the operation. Traction sutures are to be preferred to hemostats or Allis clamps because they are far less damaging to the friable pancreatic tissue. The jejunum is approximated to the posterior aspect of the pancreas by means of a suture line composed of interrupted fine silk sutures placed as shown (Fig 1 (1)). These are placed deeply in the substance of the gland, include the jejunal submucosa, and are tied loosely in order to avoid jeopardizing the blood supply of the included tissues.

As shown in Figure 1 (2), the clamp upon the jejunum is next removed, its bite of necrotic tissue carefully excised, and the posterior cut-border of the pancreatic stump approximated to the adjacent jejunal mucous membrane, again, with interrupted sutures of fine silk. Similarly, the anterior cut-borders of the pancreas and jejunum are approximated as shown in Figure 1 (3). Just prior to the completion of this third row of sutures the fine silk ligature securing the pancreatic duct is removed, establishing immediate drainage into the lumen of the jejunum. By gentle manipulation the stump of the pancreas is then actually introduced into the inverted end of the jejunum. This inversion is then maintained by a fourth row of interrupted fine silk sutures, comparable to the first row, as shown diagrammatically in Figure 1 (4).

Brunschwig⁸ has recently raised the question "of whether appreciable pancreatic secretion may obtain after such implantations." That appreciable amounts of pancreatic secretion do gain entrance to the gastro-intestinal tract following this procedure is indicated, first, by the experimental studies of Person and Glenn,¹⁴ in which a perfectly functioning pancreaticogastrostomy was demonstrated following implantation of the stump into the posterior wall of the stomach, second, by Case 4, in which the presence of pancreatic enzymes was demonstrated in the intestinal tract by means of the secretin test, third, by Cases 4, 5, 6 and 7, in which there has been no evidence of digestive disturbances following operation. In these four cases there has been no instance of the development of a postoperative pancreatic fistula, a most undesirable complication not only from the point of view of the difficulty involved in the management of the fistula itself, but also because of the danger of severe hemorrhage associated with the escape of pancreatic juice into the site of a but recently completed operation.

Gastrojejunostomy—Judging from the reported cases and from this series, much latitude may be exercised in reestablishing the continuity of the

stomach and jejunum. As a matter of principle a stoma so placed as to prevent the enteric stream from passing either the pancreatic or biliary anastomosis is to be preferred. In Case 4 it is noted that the cholecystojejunostomy lay distal to the gastro-enterostomy. This may well have been a factor contributing to this man's episodes of biliary tract infection. At the present time an effort is made to place the gastro-enterostomy as illustrated in Cases 5, 6 and 7. Whether ante- or retrocolic would appear to be of minor significance.

Suture Material—Throughout all of these radical procedures silk has been used entirely except for the mucosal suture in the biliary and gastric anastomoses. Particularly is the use of silk important in performing not only the pancreatic anastomosis but also in securing hemostasis, for catgut is digested with amazing rapidity by pancreatic juice. It is probable that much of the current pessimism expressed toward pancreatico-enterostomies finds origin in the poor results obtained at a time when catgut was used almost exclusively.

Closure of the Abdominal Wall—In this entire series, with the exception of the last case, all of the abdominal wounds were closed with through-and-through silver wire stay-sutures together with catgut approximating the individual layers.¹³ Although several of these individuals developed rather severe wound infections there was no case in which wound disruption or evisceration occurred. The last case was closed with buried double medium silk securing all layers with a modified on-end mattress suture. The significant factor in wound closure in these patients is considered to be the inclusion of some form of nonabsorbable suture that will permit adequate wound drainage, without the risk of disruption should infection occur.

Drainage—It is important to secure drainage of the site of the pancreatic anastomosis. This is performed by preference through a stab wound in the flank, placing the drains to the neighborhood of, though not actually to, the pancreaticejejunostomy suture line. This suture line incidentally can usually be reasonably well protected by an adjacent tab of omental or retroperitoneal fat.

Anesthesia—Open-drop ether was employed with satisfaction in all of these patients save the last (Case 4) in which continuous spinal was administered. Because of the many advantages associated with the latter agent, it may become the anesthesia of choice in the future.

CLINICAL ABSTRACTS OF CASE REPORTS

Case 1—N Y H No 277074 R A, age 57, male

Diagnosis Carcinoma of ampulla of Vater

History This 57-year-old white male gave a history on admission of vague upper abdominal distress of three weeks' duration, associated with the onset of jaundice a week later, and a weight loss of ten pounds.

Physical Examination Revealed a poorly nourished man, moderately jaundiced. On abdominal examination the liver edge was palpable 4 cm. below the right costal margin.

Laboratory The only significant finding was the presence of bile in the urine. The stools were light brown and negative for blood.

Roentgenology Negative G. I. series.

Operations First—September 17, 1940 Exploratory celiotomy led to the discovery of a movable tumor of the ampulla of Vater A posterior gastro-enterostomy and a cholecystogastrostomy were performed as a first-stage Whipple procedure

Second—September 30, 1940 Transduodenal local excision of a carcinoma of the ampulla of Vater, with implantation of the common and pancreatic ducts Because of the small size of the ampullary tumor it was not considered necessary to subject this patient to the hazards of the second-stage Whipple operation, *i.e.*, radical pancreaticoduodenectomy

Follow-up 1 year—Well Back at work No complaints

2 years—Well Back at work No complaints

3 years—Well Back at work No complaints

3 1/2 years—Patient beginning to complain of loss of appetite and of weight, together with upper abdominal pain Physical examination negative A definite diagnosis of recurrence cannot be made at this time, but in view of the patient's difficulties it seems probable

Case 2—N Y H No 276140 F B, age 56, female

Diagnosis Carcinoma of ampulla

History Mother and one brother died of carcinoma

This 56-year-old housewife gave a history of progressive loss of appetite of two and one-half months, and of mild jaundice and pruritis of two months She became deeply jaundiced one week before admission No weight loss

Physical Examination This revealed an obese white female who was deeply jaundiced On abdominal examination the liver was palpable one centimeter below the right costal margin

Laboratory The significant finding was a positive reaction for blood in the stools

Roentgenology Negative G I series

Operations First—September 9, 1940 Duodenotomy and biopsy of ampullary tumor Ligation of common duct Posterior gastrojejunostomy Cholecystogastrostomy

Postoperative Course Unremarkable Icteric index became normal

Second—October 15, 1940 Partial resection of duodenum and head of the pancreas Closure of duodenal and pancreatic stumps

Postoperative Course Developed a duodenal fistula, draining as much as 5000 cc a day

Third—October 31, 1940 Unsuccessful attempt to close the duodenal stamp

Postoperative Course Persistent duodenal fistula

Fourth—November 15, 1940 Jejunostomy for enteric feeding

November 29, 1940—Postoperative death due to inanition and sepsis

Postmortem Examination Duodenal fistula and localized abscess

Case 3—N Y H No 254422 P DM, age 52, male

Diagnosis Carcinoma of head of the pancreas

History This 52-year-old white male gave a history of progressive painless jaundice of four months' duration, associated with a weight loss of 30 pounds

Physical Examination Revealed a deeply jaundiced white male, with an enlarged easily palpable, nontender gallbladder

Laboratory The stools were negative for blood The prothrombin was 48 per cent, rising to 70 per cent after administration of vitamin K

Roentgenology G I series revealed a mucosal irregularity in the second portion of the duodenum

Operations First—January 15, 1940 Cholecystogastrostomy and posterior gastro-enterostomy

Second—February 1, 1940 Resection of pancreatic head and first and second portions of duodenum Closure of the pancreatic stump

PANCREATICOJEJUNOSTOMY

Postoperative Course Patient developed both a pancreatic and biliary fistula which closed spontaneously after five months, only to break open again within one week. An attempt to resect and reimplant the fistulous tract was unsuccessful, and the patient finally died after eight months of all but continuous hospitalization. During the entire postoperative period he was unable to digest fat, as manifested by persistent steatorrhea.

Case 4—N Y H No 311583 J B, age 57, male (Previously reported⁸)

Diagnosis Carcinoma of duodenum

History This 57-year-old white male presented himself complaining of jaundice, cutaneous pruritis, and a weight loss of 20 pounds over a course of one month.

Physical Examination Revealed a well-developed and well-nourished jaundiced male. On abdominal examination the liver edge could be felt 3 cm below the right costal margin and the gallbladder was easily felt.

Laboratory Hb 10 Gm R B C 3.8 M W B C 9,050 Urine Bile present Stools positive for blood Prothrombin time 61 per cent rising to 100 after vitamin K.

Roentgenology G I series revealed marked irregularity of the mucosal pattern in second and third portions of the duodenum.

Operation November 28, 1941. Radical partial pancreatectomy and duodenectomy. The enteric canal was reestablished first by retrocolic pancreaticojejunostomy, then an antecolic gastrojejunostomy and, lastly, an antecolic cholecystojejunostomy. The right gutter was drained through a stab wound in the flank.

Postoperative Course Patient developed an atelectasis followed by pneumonia. He was discharged well 30 days after operation.

During the next 12 months the patient was readmitted twice because of rather severe attacks of acute cholangitis. Fourteen months after his initial operation he was readmitted because of reappearance of his jaundice. Exploratory celiotomy revealed extensive intra-abdominal carcinomatosis, the patient died several weeks later. At postmortem examination an effort to examine the pancreaticojejunostomy was unsuccessful because of massive replacement with tumor.

Case 5—N Y H No 361219 W M, age 69, male

Diagnosis Carcinoma of ampulla of Vater

History This 69-year-old white male presented himself with a history of the sudden onset of jaundice six weeks prior to admission. As the jaundice increased he lost his appetite and 30 pounds in weight.

Physical Examination Revealed an intensely jaundiced, somewhat senile male in no acute distress. B P 175/90. Examination of the abdomen revealed a liver palpable 3-4 cm below the right costal margin.

Laboratory Urine Bile present Stools positive for blood Prothrombin 45 per cent rising to 80 per cent after vitamin K.

Operation July 3, 1943. Resection of the head of the pancreas and duodenum. In succession, a retrocolic anastomosis was performed between the pancreas and jejunum, end-to-end, between the gallbladder and jejunum, side-to-side, and between the open end of the stomach and the side of the jejunum.

Postoperative Course This was complicated by extensive suppuration of the abdominal wound. This subsided under adequate therapy, and the patient was discharged well on the 42nd day after operation.

Follow-up Gained 30 pounds. No digestive disturbance. Entirely well one year after operation.

Case 6—N Y H No 363096 S H, age 55, female

Diagnosis Carcinoma of ampulla of Vater

First Admission History This 55-year-old Italian female gave a history on admission of intermittent painless jaundice of five weeks' duration. No loss of appetite. No weight loss.

Physical Examination Revealed a well-developed and well-nourished woman who was moderately jaundiced B P 150/70 Abdomen No masses or solid viscera palpable

Laboratory Urine strongly positive for bile Serum proteins 4.8 Gm/100 cc Stools positive for blood Hb 12.2 Gm R B C 3.8 M W B C 14,000 Prothrombin 78 per cent rising to 92 per cent after vitamin K

Preoperative Care Three transfusions

Operation August 17, 1943 At exploration of the ampulla through a duodenotomy, a small soft adenomatous tumor was found which did not appear malignant either in the gross or upon frozen-section Accordingly, a presumably complete local excision was performed transduodenally and the common and pancreatic ducts reimplanted

Postoperative Course Her jaundice cleared rapidly and she was discharged well on her 18th postoperative day

Second Admission Within three weeks after discharge she again became jaundiced, and was readmitted to the hospital

Physical Examination On this admission an enlarged gallbladder was easily palpable

Laboratory Icteric index 152

Second Operation December 20, 1943 two months after local excision At exploration a firm tumor mass occupying the head of the pancreas was discovered In spite of the numerous adhesions due to the previous operation the lesion could be easily mobilized and was subjected to radical pancreaticoduodenectomy in one stage In succession, the following retrocolic anastomoses were performed Pancreas and open end of jejunum, choledochus and jejunum, end-to-side, and stomach to jejunum, end-to-side A small tube was placed in the gallbladder as a safety valve for the biliary tract

The postoperative course was unremarkable The patient was discharged on her 21st postoperative day

Case 7—N Y H No 375553 W H J M, age 65, male

Diagnosis Carcinoma of stomach invading head of the pancreas

History On admission the patient's complaint was one of persistent epigastric fullness after ingestion, even of liquids, for the previous two months

Physical Examination Poorly nourished white male in no distress B P 150/98 On examination of the abdomen a hard, freely movable mass could be felt in the right upper quadrant

Laboratory Urine 2 plus sugar Fasting blood sugar 150 mg/100 cc Hb 80 per cent R B C 4.5 M W B C 7,800 Plasma proteins 6.5 Gm/100 cc Stool repeatedly positive for blood

Roentgenology G I series led to a diagnosis of carcinoma of the pyloric end of the stomach with 75 per cent retention at six hours

Operation January 6, 1944 On exploration an obvious carcinoma of the pyloric end of the stomach was found Since the only evidence of extension was into the head of the pancreas a subtotal gastric resection (three-quarters of the stomach) was performed, together with removal of the head of the pancreas and duodenum A retrocolic pancreaticojejunostomy and choledochojejunostomy was performed, and an antecolic long loop gastrojejunostomy Drainage to the right gutter was established through a stab wound

Postoperative Course Unremarkable The patient was discharged well on the 14th postoperative day At two months he is entirely well, having gained over 15 pounds

SUMMARY

(1) Five previously unreported cases of carcinoma involving the head of the pancreas which have been treated radically are recorded

(2) Some form of pancreaticojejunostomy following partial pancreatic-

otomy is recommended, and a method is outlined which has proved satisfactory in four cases

(3) A case of subtotal gastric resection and radical pancreaticoduodenectomy for carcinoma of the stomach invading the head of the pancreas is reported

(4) Various other problems associated with radical extirpation of cancer involving the head of the pancreas are discussed

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NEUROGENIC SARCOMA OF THE JEJUNUM ASSOCIATED WITH VON RECKLINGHAUSEN'S DISEASE

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REPORTED INSTANCES of neurogenic sarcoma of the small intestine are rare. The following account deals with such a lesion in the jejunum, discovered by preoperative roentgenograms and successfully resected. The patient also had von Recklinghausen's disease, with multiple cutaneous and subcutaneous nodules and scoliosis of the dorsolumbar spine. The jejunal tumor did not cause obstruction but first gave notice of its existence through small hemorrhages.

Case Report—A 37-year-old, white, male officer was transferred to an Army General Hospital because of intestinal hemorrhage and secondary anemia. About six weeks previously he had first noticed the passage of dark blood in his stools. At that time he also was having cramp-like abdominal pains in the lower left quadrant, relieved by heat but no constipation or diarrhea. On admission to a Station Hospital, April 30, 1943, the R B C was 2.5 million, W B C 4,800, urinalysis and Kahn test negative, and stool positive for occult blood. No tenderness or masses were found on abdominal examination. During his stay there, a G-I series and two barium enemas, including air-contrast study of the colon, were all reported negative. One week after admission the R B C was 3.3 million, with 46 per cent hemoglobin. This secondary anemia responded to therapy with iron and liver extract. Occult blood continued to be present in the stools.

On May 29, the patient had a sudden large intestinal hemorrhage, and was found lying in a pool of fresh blood and clots which he had passed by rectum. The R B C dropped from 3.3 to 2.7 million, and the hemoglobin from 60 to 55 per cent. The next day sigmoidoscopy was done but no abnormalities were found.

One week after the hemorrhage, June 5, 1943, he was transferred to a General Hospital. The stools were positive for occult blood for the next ten days but negative thereafter. Aided by iron therapy his anemia steadily improved. Roentgenologic studies of the upper gastro-intestinal tract revealed a large filling defect approximately in the upper half of the jejunum, with moderate dilatation of the intestine above it (Fig 1). This seemed to be caused by a tumor projecting both into the lumen and outwards beneath the serosa. It was causing relatively little obstruction and the barium readily passed by, outlining the fungating intraluminal portion. A roentgenogram of the chest showed the lung fields to be clear.

This jejunal tumor was considered to be a neurofibroma or neurogenic sarcoma, a part of the generalized von Recklinghausen's disease with which the patient was afflicted (Fig 2). There were innumerable small and medium-sized nodules in and beneath his skin, mostly on the chest and abdomen. Some were solid, others felt cystic, still others were pendulous tabs, among them were numerous patches of brown pigmentation. He first noticed the nodules about six years ago, and they continued to appear over a period of two years. The history records no other instance of von Recklinghausen's disease in his family.

NEUROGENIC SARCOMA OF JEJUNUM

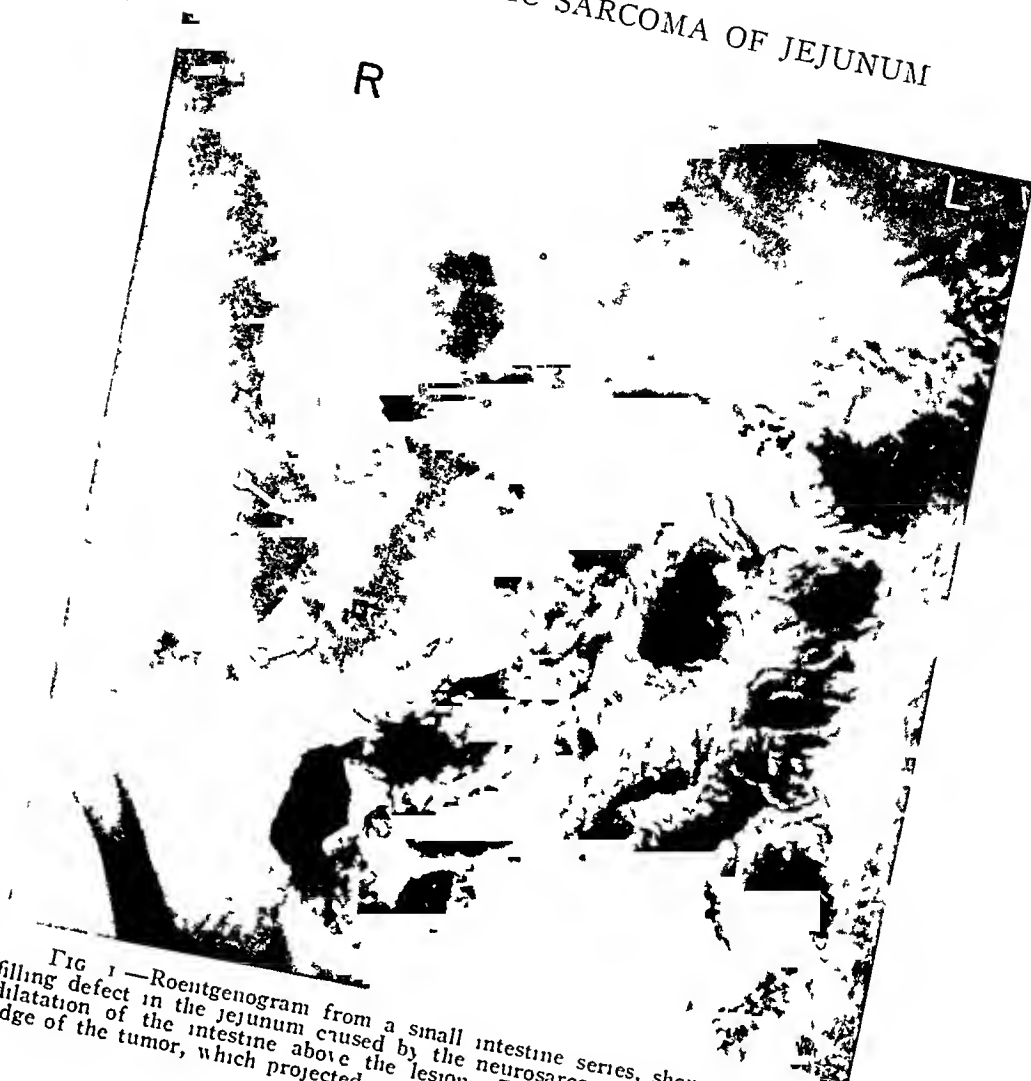


FIG. 1—Roentgenogram from a small intestine series, showing the large filling defect in the jejunum caused by the neurosarcoma. Note the moderate dilatation of the intestine above the lesion. The arrows point to the outer edge of the tumor, which projected into the peritoneal cavity.

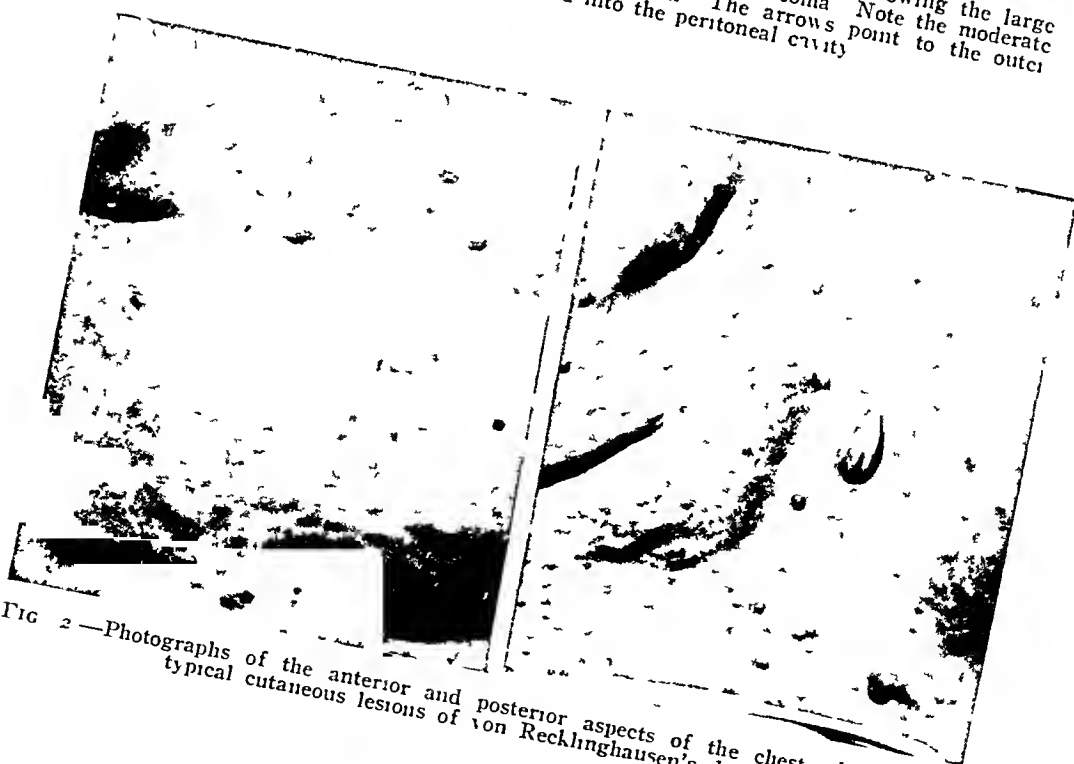


FIG. 2—Photographs of the anterior and posterior aspects of the chest, showing the typical cutaneous lesions of von Recklinghausen's disease.

The patient also had rather marked scoliosis of his dorsolumbar spine, which had been present since childhood but had never caused him pain or restricted his activities. Roentgenograms during his hospital stay showed the curvature but no congenital anomaly, and no evidence of an inflammatory or destructive process. A survey of the other bones and joints revealed no significant abnormal changes.

Two of the superficial lesions were removed for microscopic study. One of them was a hard, movable, subcutaneous nodule composed of firm, yellowish-gray tissue. Microscopically, there was "rather loose fibrous tissue surrounded by a dense hyalin fibrous tissue capsule." Many of the cells were spindle-shaped, and this arrangement resembled that seen in a neurofibroma. The other was a cutaneous pedunculated growth, "composed of loose edematous fibrous tissue covered with ordinary epithelium."

An abdominal operation was later performed and the jejunal tumor resected. On opening the peritoneal cavity, no free fluid was encountered, and the liver, spleen, kidneys, stomach, and large bowel were normal. In the upper jejunum, approximately two feet below the ligament of Treitz, there was a tumor involving the antimesenteric border of the bowel, about three inches in diameter, with enlarged soft lymph nodes distributed throughout the adjacent mesentery and in the aortic group. One piece of omentum was adherent to the bowel and was fixed. The tumor and two inches of bowel on each side were excised and a side-to-side anastomosis constructed.

Pathologic Examination—Gross. The specimen was opened along the mesenteric border, disclosing a large, fungating tumor mass, 7.5 × 6.5 × 3 cm in size, projecting into the lumen (Figs 3 and 4). The mass was canalized so that there was a ring of tumor tissue around the entire circumference within the bowel, though attached to the wall only at its base (Fig 5). Two channels were thus present: a small one through the tumor, about 1.5 cm in diameter, and a narrow slit between the free edge of the tumor and the uninvolved intestinal wall. No frank ulceration was noted. The tumor also projected from the serosa, forming an irregular, lobulated mass about 5 cm in diameter. No lymph nodes were included with the specimen.

Microscopically (Fig 6), the tumor was "composed of cells having elongated spindle-shaped or fusiform nuclei arranged in interlacing strands or bundles. The tumor is quite cellular. There is very little anaplasia. A few irregular mitoses are present. Although the tumor appears relatively benign, the cellularity and mitoses indicate that it should probably be considered as a neurogenic sarcoma." *Pathologic Diagnosis:* Neurogenic sarcoma of jejunum."

This histologic diagnosis was confirmed by the Army Medical Museum, with the additional observation that "from the clinical standpoint there should be no further complication from the removal of this tumor since such tumors rarely metastasize."

The patient rapidly recovered from the operation, and there were no complications during the postoperative period. Within three weeks the wound was entirely healed and the patient was ambulatory, eating his meals and gaining weight. After a month's sick leave, he was in excellent condition and returned to his duties.

We have not attempted to make a complete list of reported gastrointestinal neurogenic sarcomas but believe a partial account would be interesting. According to Ewing,¹ Sarazanes collected reports of such tumors affecting the tongue, stomach, jejunum, ileum, and colon.

Hosoi's² study of the literature revealed five cases which are considered neurosarcoma, though originally some were given other names.

Adrian (1902) Fibrosarcoma of the duodenum, associated with multiple fibromas of skin and internal viscera and neuromyoma of supraclavicular fossa.

Kohtz (1893) Sarcomatous tumor of duodenum, nodules on surface of stomach and several subserous nodules in small intestine and mesentery.

NEUROGENIC SARCOMA OF JEJUNUM



Fig 3—Photograph of the excised tumor, showing the lobulated, subserosal portion which protruded into the peritoneal cavity



Fig 4



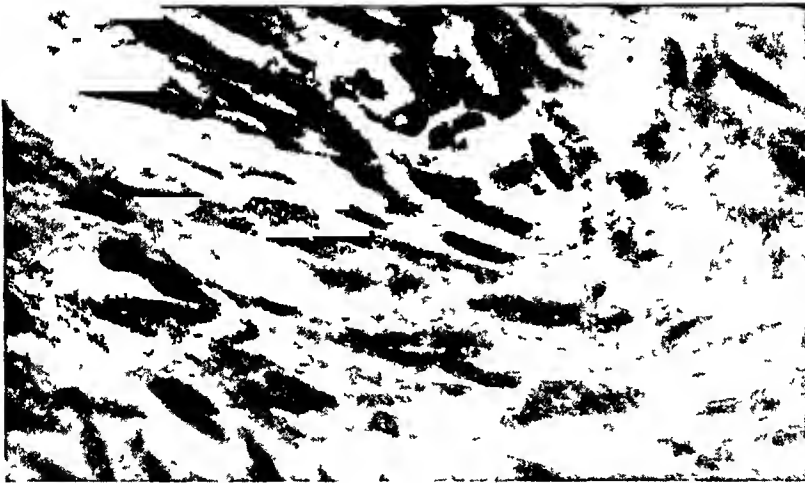
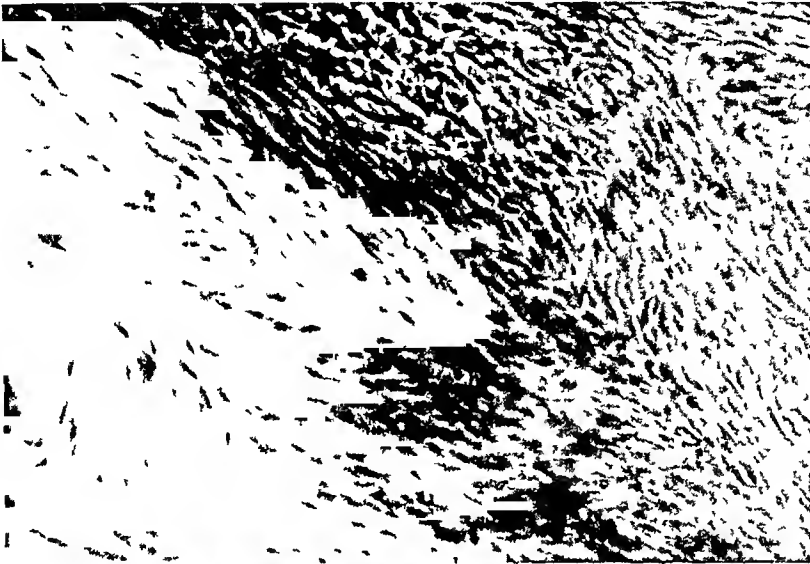
Fig 5

Fig 4—The fungating, intraluminal portion of the sarcoma
Fig 5—A ruler has been passed through the extra lumen formed by canalization of the tumor

Shouldice (1925) Fibromyxosarcoma on greater curvature of stomach in a case with multiple peripheral fibromas and many millet-seed, nodular tumors on surface of stomach

Hartman (1927) Fibromyxosarcoma of stomach, believed to have arisen in a neurofibroma of the gastric wall, in a patient with von Recklinghausen's disease

(a)



(b)

FIG 6—(a) Photomicrograph of the jejunal neurosarcoma, showing the nuclei arranged in interlacing strands and bundles

(b) High power view, showing the spindle shaped and fusiform nuclei. The tumor is quite cellular, though there is very little anaplasia

von Recklinghausen (1882) Sarcoma of jejunum in a case of neurofibromatosis (two of the largest nodules on the jejunum were sarcomatous)

Geschickter,³ in his analysis of 1472 malignant tumors of the gastrointestinal tract, found 50 cases of sarcoma, ten of which were "nerve sheath sarcomas". Of these ten, three were in the stomach, three in the small intestine and four in the rectum, one of the small intestinal sarcomas was associated with von Recklinghausen's disease. Bergendall and Sjoval⁴ reported

a case of resected neuinoma of the ileum, 8 cm in diameter, which had ruptured from central necrosis and given rise to acute peritonitis. Three years after removal of the tumor, generalized abdominal metastases developed. At autopsy, the disseminated peritoneal lesions were said to show the characteristic histologic aspects of neuinoma, but malignant alteration was indicated by the numerous mitotic figures.

Miller and Frank⁵ present two well illustrated case reports of "neurofibrosarcomas" of the jejunum. In the first (a female, age 72, with no personal or family history of von Recklinghausen's disease), there was a large, lobulated, medullary tumor attached to the antimesenteric border of the jejunum. Six months after resection she was reported well. The second case (a male, age 47, also without family history of von Recklinghausen's disease, and without cutaneous lesions), presented a large mass beneath the ligament of Treitz and multiple tumors of the jejunum and ileum, mesentery, and retroperitoneal nodes. Most of them (about 26) were in the intestinal wall, varying in diameter from 0.5 cm to 10 cm, projecting either inward or outward. A few were ulcerated and one large lesion, at autopsy, formed a "truncated tumor, replacing the bowel, with a lumen through it." The microscopic diagnosis was neurofibrosarcoma, multiple, of small intestine, with metastases to mesenteric and retroperitoneal lymph nodes.

Grill and Kuzma⁶ have recently reported an interesting case, though not of a sarcoma. There was a large ileal neurofibroma in a patient with von Recklinghausen's disease. The tumor was the origin of severe, intermittent, intestinal hemorrhages, which finally caused death. It arose in the wall of the ileum and protruded into the peritoneal cavity, drawing a pouch of epithelium with it. Many thin-walled blood spaces next to the intestinal epithelium, some of them eroded, were apparently responsible for the bleeding. The authors included an extensive bibliography, together with a discussion of benign intestinal tumors and von Recklinghausen's disease.

DISCUSSION—The whole subject of neurofibromatosis, tumors of peripheral nerves and neurogenic sarcoma is complex and controversial. The main features of von Recklinghausen's disease are well known, but the associated skeletal, visceral and endocrine manifestations are ill defined. Problems of histogenesis are unsettled and classifications are numerous, elaborate and conflicting. Some authors hold that the Schwann cell plays the predominant part in the growth of neurogenic sarcoma while others believe it is the fibroblast. For a lucid, authoritative review, in which the various threads of discussion and debate are skillfully drawn together, we recommend the chapter in the treatise by Ewing.¹

In von Recklinghausen's disease several types of lesions are encountered. The most common and characteristic are the multiple cutaneous and subcutaneous neurofibromas, similar multiple tumors are also found along the deeper nerves and in the mucous and serous membranes and viscera. In the skin the nodules are usually accompanied and often preceded by coffee-colored areas of pigmentation. Two other types of lesions are the plexiform neuroma

and elephantiasis neuromatosa. Occasionally, there is also the neurinoma, though this is more often solitary. This is an encapsulated tumor, mainly of the larger nerve trunks, occurring in the subcutaneous and muscular tissues of the limbs and in various internal structures. It has a distinctive histologic pattern ("palisade units"). Neurogenic sarcoma, or neurosarcoma, develops in about 13 per cent of the cases of von Recklinghausen's disease, according to Hosoi.² In addition, many other organs and systems are directly or indirectly affected as a part of the disease—brain, meninges, spinal cord, vascular system, cutaneous structures, and bones. The osseous changes^{7, 8} are frequent and include scoliosis (most common), localized hypertrophy and other abnormalities of growth, and subperiosteal cysts.

Our patient had the typical cutaneous and subcutaneous neurofibromas, mostly on his trunk. Among them were numerous pigmented areas of "*café au lait*" color and probably some small lipomas and fibromas. There was no plexiform neuroma or elephantiasis. He had a marked scoliosis but no other bony abnormalities. Although many cases of von Recklinghausen's disease are inherited, there is no recorded history of the malady in our patient's family.

The most interesting feature of the case is the neurosarcoma of the jejunum, especially its location. Malignant tumors of the nerve trunks are not uncommon and they may occur anywhere. The great majority, however, show a predilection for the subcutaneous and deeper intermuscular tissues of the limbs, including the shoulders and hips. Only a few neurosarcomas have been described in the gastro-intestinal tract, and jejunal examples are quite rare.

In this location they arise in the wall of the intestine, protruding into the lumen or outward into the peritoneal cavity. Often they grow in both directions, as in our case. The mucosa covering the intraluminal growth may be intact or ulcerated. When ulceration is present, the resultant hemorrhage may be very severe. Intestinal obstruction has occurred, but it has usually been incomplete, since these sarcomas are fungating rather than annular and constricting. In our case, an additional safety factor was a narrow channel running through the polypoid tumor, providing a second and extra lumen for the passage of the intestinal contents. The tumors may cause intussusception, as illustrated by Miller and Frank's⁵ second case. They may also perforate, especially if the interior of the sarcoma is necrotic (Bergendal and Sjoval⁴).

Neurogenic sarcomas frequently occur in conjunction with von Recklinghausen's disease. In Stewart and Copeland's⁹ series of neurosarcomas 21 out of 104 cases (20 per cent) were associated with one or more stigmata of the generalized disease. Stout¹⁰ maintains the incidence is very much higher, and that careful search and recording will establish the presence of pigmentation or a few skin tumors in many more cases. The majority of these malignant tumors, he believes, develop in preexisting neurofibromatous nodules, though this is often difficult or impossible to prove. The neurinomas rarely become malignant.

The anatomic, microscopic and clinical features of neurogenic sarcomas are fully described by the above authors^{9, 10} and Geschickter,¹¹ and summarized by Ewing. Most of this knowledge has accumulated from study of sarcomas of the peripheral nerve trunks, which are by far the most numerous. Briefly, the features are (1) Sudden, rapid enlargement of an old tumor, (2) prolonged, persistent growth, (3) recurrence in original site after incomplete removal, (4) frequent appearance, after local excision, of a new tumor or tumors higher up the same nerve trunk, either arising independently, or from extension along the nerve within the epineurium, (5) complications and death may occur from the local lesion, because of ulceration, infection, hemorrhage, or invasion of vital structures, (6) metastasis in about 20 per cent of cases, usually hematogenous to lungs, (7) rare involvement of regional lymph nodes, (8) better prognosis of encapsulated tumors, and (9) wisdom of amputation after repeated occurrences. Ewing divides the tumors into three histologic types: Sclerosing, spindle cell, and cellular anaplastic neurosarcomas. The tumor in our case fits into the second, intermediate, type.

The treatment and prognosis are also discussed by these authors. Ewing¹ concludes with the statement: "On account of the bad prognosis of most sarcomas of the soft parts, and the radiosensitivity of many, especially the more malignant ones, a program should be adopted of diagnosis by aspiration and thorough radiation before surgery is employed."

SUMMARY

A case is presented of neurogenic sarcoma of the jejunum in a patient with von Recklinghausen's disease. The tumor caused intestinal bleeding, and was successfully resected.

The rarity of this type of tumor in the jejunum, its association with von Recklinghausen's disease, and the general subject of neurogenic sarcomas are briefly discussed.

The authors extend their thanks to Lt. Col. John M. Wellman, M.C., the surgeon who performed the operation, and to Lt. Col. Perry T. Hough, M.C., the pathologist, for their cooperation in assembling data for the case report.

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ESTIMATION AND SIGNIFICANCE OF BLOOD LOSS DURING GASTRO-INTESTINAL SURGERY*

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ALTHOUGH by the application of newer surgical techniques the problem of blood loss during operations has ceased to be formidable, nevertheless its accurate estimation is frequently worth while. This is particularly true in anemic patients with cardiovascular insufficiency. These individuals sometimes cannot spare even a small amount of blood, yet its replacement by transfusions, when overestimated in amount, may induce cardiovascular collapse.

The determination of blood loss cannot accurately be made from the postoperative concentration of hemoglobin or the red cell count. It is a well-proven fact that the total blood volume is very labile, and after operative hemorrhage it frequently may shrink in an attempt to maintain the pre-operative concentration of blood. A comparison of the pre- and postoperative blood counts, therefore, cannot be substituted safely for an accurate estimation of the blood shed during surgical procedures. Since the repeated determination of total blood volume *in vivo* is often a difficult procedure, the more feasible determination is the direct measurement of blood loss.

Quantitative determinations of blood loss during some common operative procedures were made by Gatch and Little¹. The method employed by these investigators was to wash promptly and repeatedly all sponges and instruments soiled with blood. Enough hydrochloric acid was then added to the pooled washings to make a final 0.1 N solution. The resulting acid hematin was compared with a standard solution of acid hematin prepared from the whole blood of the patient before operation.

More recently, White and Buxton² employed a modification of the acid hematin technic to determine blood loss during intrathoracic surgical procedures. Their method entailed the recovery of all blood from linens, sponges, and instruments by extraction with distilled water. Nine cubic centimeters of this solution were converted to acid hematin by the addition of 1 cc of 1 N hydrochloric acid. This last solution then was compared colorimetrically with a standard prepared from 1 cc of the patient's blood in which the hemoglobin was converted to acid hematin by the addition of 9 cc of 0.1 N hydrochloric acid. By this technic about 86 per cent of the hemoglobin could be recovered.

* Read before the New York Surgical Society, December 8, 1943. Paper No. 22 in a series of metabolic studies on patients with cancer of the gastro-intestinal tract.

A simple and ingenious approach to the problem recently was offered by Wangenstein³. The gain in weight of a known amount of dry linens and sponges used during operation is converted into cubic centimeters of blood absorbed by reference to the specific gravity of the patient's blood. The technic is claimed to be accurate to within a few per cent. Moreover, the use of dry sponges apparently does not impose a serious handicap to the surgeon. Large packs which are kept moist to keep a minimum of fibrin formation on the bowel are employed to cover the intestine. The method offers the further advantage that at any time during the operation the surgeon can be informed of the blood lost up to that point. By this procedure, Wangenstein has found that the usual blood loss consequent to gastric resection varies from 300 to 500 cc.

In the present study an attempt has been made to incorporate the best features of the above methods, and at the same time to keep the technic simple enough to be employed by the average hospital technician.⁴

METHOD

All blood-soaked linen and sponges are meticulously collected in a single container. As soon after the end of the operation as possible, the blood is extracted from these materials by the repeated addition (ten times) of tap water. All washings are pooled, and the total volume measured. An aliquot of this is filtered and provides the solution for measurement in a photo-electric colorimeter (Klett-Summerson, Filter No. 52).

The standard curve for this comparison is constructed by the measurement of several dilutions of a normal blood found to contain 13.8 Gm. of hemoglobin by the Sahli technic.⁴

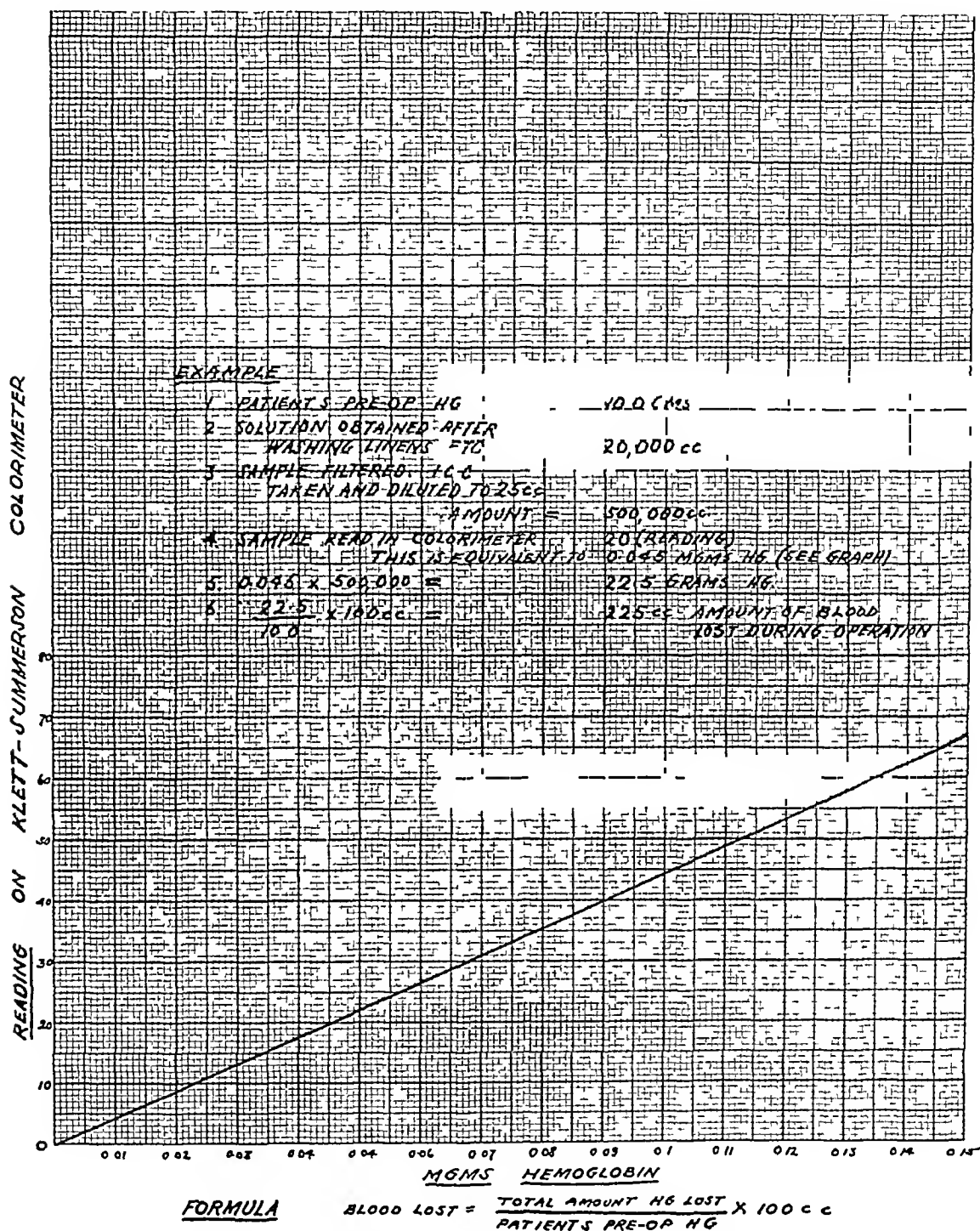
The concentration of hemoglobin in the blood of the patient is necessarily determined preoperatively. From these values, it is possible to ascertain the volume of blood lost during the surgical procedure. A sample calculation is appended.

Sample 1	Patient's preoperative hemoglobin	10 Gm per cent
2	Volume of solution obtained after washing linens, etc	20,000 cc
3	Sample filtered. It was deemed necessary to dilute one cc of this to 25 cc since the reading lay outside the graph limits. Therefore, the total amount of hemoglobin solution is	500,000 cc
	(This is not always a necessary step)	
4	Sample is read in the Klett-Summerson colorimeter. The reading is	20
	From standard curve, this represents	0.045 mg Hb
5	0.045 x 500,000 equals	22.5 Gm Hb
6	Therefore $\frac{22.5}{10} \times 100$ cc equals the amount of blood lost	
	during the operation	225 cc

* All operations listed were performed by a single surgeon (G. T. P.) so the comparative values of blood loss should be significant.

CANCER OF GASTRO-INTESTINAL TRACT

CHART I



The accuracy of the method was determined by the recovery of known quantities of blood from samples of linen and sponges. The hemoglobin recovered after ten washings was found to vary from the known amount by no more than 6 per cent.

RESULTS

A BLOOD LOSS DURING OPERATIONS TO SERVE AS CONTROL DATA FOR GASTRO-INTESTINAL PROCEDURES

Information concerning the quantity of blood lost during operation chiefly for cancer of the gastro-intestinal tract becomes more valuable and significant

when the figures so obtained are compared with the blood loss sustained during other common operations performed by the same surgical team. From this viewpoint of blood loss, the average major operation on the gastro-intestinal tract compares favorably with such procedures as hip joint disarticulation (300 cc) and splenectomy (160 cc). Hysterectomy, on the other hand, is a relatively bloodless operation. Radical vulvectomy with bilateral groin dissection (725 cc) and radical mastectomy (average 600 cc) entail a considerable blood loss with minor shock in spite of scrupulous care to maintain hemostasis (Table I).

 TABLE I
CONTROLS

The Following Operations Used to Standardize Procedure

The Following Operations Used to Standardize Procedure		11b				Hb
		13.8 Gm	Blood	Surg		First
		≈ 100	Loss	Est	Trans	Day
Patient	Operation	Per Cent	Cc	Cc	Cc	Postop
F S	Bilateral groin dissection and vulvectomy	9.7	725	600	640	9.8
T B	Hip disarticulation	11.0	300	150	600	
J G	Amputation mid thigh without tourniquet	11.0	410	350	0	
G O	Radical mastectomy	11.0	650	1200	0	9.7
D M	Radical mastectomy	9.7	475	500	600	8.3
B T	Radical mastectomy	11.7	700	500	250	10.2
M B	Splenectomy	9.5	160	150	600	13.0
G B	Supracervical hysterectomy and appendectomy	10.2	40	50	0	
C B	Supracervical hysterectomy, appendectomy and bilateral salpingo oophorectomy	10.2	90	100	0	10.2
B M	Supracervical hysterectomy	13.5	135	175	0	
M H	Pan hysterectomy	9.7	165	175	0	
A B	Resection jejunal diverticulum	11.0	50	100	695	9.0

B GASTRO-INTESTINAL OPERATIONS

The amount of blood lost during the simple procedure of gastrostomy or enterostomy varied only from 15 to 75 cc (Table II). In one instance, however, the formation of a Spivack gastrostomy entailed a loss of 305 cc, inasmuch as this procedure was employed for a markedly adherent and inoperable cancer of the gastric cardia, this value was not unexpected.

 TABLE II
THE BLOOD LOSS DURING PALIATIVE OPERATIONS FOR GASTRIC CANCER

Patient	Operation	Hb Gm Per Cent Preop	Blood Loss Cc	Surg Est Cc	Blood Given at Op eration	Hb Per Cent First Day Postop
R H	Janeway gastrostomy for ca. cardia	11.0	75	150	None	
H P	Spivack gastrostomy for ca. cardia	11.7	305	300	600	11.7
F P	Beck-Jianu gastrostomy for ca. cardia	9.7	50	50	600	9.7
J B	Jejunostomy for ca. stomach	13.8	15	25	600	10.4
A H	Gastro enterostomy	11.7	45	75	None	10.2
J F	Exclusion operation and gastrojejunostomy for ca. stomach	9.3	100	150	600	10.2
J O	Exclusion operation and gastrojejunostomy for ca. stomach	13.0	250	300	600	12.0
	Average		120			

The average amount of blood lost during total gastrectomy was only 194 cc (Table V). This is even less than that found for the group submitted to subtotal gastrectomy for cancer, namely 234 cc (Table IV). The explan-

ation of this difference can be attributed to the small amount of bleeding encountered during transection of the abdominal esophagus as compared with the much wider transected stomach. The transthoracic approach for operable cancers of the cardia apparently does lead to a considerable blood loss, namely 450 and 475 cc. in two instances in which this was determined.

TABLE III
TILL BLOOD LOSS DURING SUBTOTAL GASTRIC RESECTION FOR ULCER

Patient	Operation	Hb Gm	Blood Loss Cc	Surg Est Cc	Blood Given at Op- eration	Hb Gm Per Cent First Day Postop
		Per Cent Preop				
M Me	Subtotal gastric resection for ulcer	11.7	270	200	650	12.1
I S	Subtotal gastric resection for ulcer	11.3	305	600	600	13.4
W O	Subtotal gastric resection for ulcer	12.1	250	300	600	13.9
W G	Subtotal gastric resection for ulcer	10.2	160	300	600	10.9
S S	Subtotal gastric resection for ulcer	11.5	150	200	None	10.5
M A	Subtotal gastric resection for ulcer	9.3	500	700	600	8.3
B R	Subtotal gastric resection for ulcer	7.6	250	350	600	11.0
R R	Subtotal gastric resection for ulcer	11.0	320	250	600	12.4
R G	Subtotal gastric resection for ulcer	10.1	300	375	600	11.7
G A	Subtotal gastric resection for ulcer	11.3	160	175	600	
	Average		267			

TABLE IV
THE BLOOD LOSS DURING SUBTOTAL RESECTION FOR GASTRIC CANCER

Patient	Operation	Hb Gm	Blood Loss Cc	Surg Est Cc	Blood Given at Op- eration	Hb Gm Per Cent First Day Postop
		Per Cent Preop				
A V	Subtotal resection for ca	13.1	300	700	600	12.1
A I	Subtotal resection for ca	13.1	365	275	600	12.1
I M	Subtotal resection for ca	13.5	175	200	600	9.2
E M	Subtotal resection for ca	10.4	160	160	600	10.9
E D	Subtotal resection for ca	11.7	190	250	600	11.7
B M	Subtotal resection for ca	7.3	225	175	650	8.1
M L	Subtotal resection for ca	8.1	250	175	650	10.8
S L	Subtotal resection for ca	9.7	210	200	600	10.9
	Average		234			

(Table VI). The greater part of this blood loss occurs in making the necessarily long intercostal incision.

The average amount of blood lost during subtotal gastrectomy for ulcer (Table III) was not significantly different from that for subtotal gastrectomy for gastric cancer. It might have been expected that the control of bleeding in patients with gastro-intestinal cancer would have been a more difficult problem since these individuals have a high incidence of hypoprolithinemia.⁷

The procedures of hemicolectomy and sigmoidectomy do not entail a great loss of blood. The average values found were 143 and 124 cc., respectively (Tables VII, VIII). Abdomino-perineal rectal resections have proven almost consistently to be relatively bloody operations (Table IX). It is not unusual for the patient to lose about 400 cc. during this procedure.

COMMENT—The accompanying tables indicate the almost constant practice of administering a blood transfusion during the course of operations for cancers of the gastro-intestinal tract. In practically every instance, however, the usual transfusion of from 500 to 600 cc. restores more blood to the patient.

than is lost during the operation. The blood given at this time is invaluable and probably is of greater value than blood given during the period of pre-operative preparation. This observation is based, of course, on clinical experience, and it is common practice today for surgeons doing this type of work seldom to request a preliminary blood transfusion unless the patient's hemo-

TABLE V
THE BLOOD LOSS DURING TOTAL GASTRECTOMY FOR GASTRIC CANCER

Patient	Operation	Hb	Blood	Surg	Blood	Hb Gm
		Gm				
		Per Cent	Loss	Est	Given	Per Cent
		Preop	Cc	Cc	at Op- eration	First Day Postop
M L	Total gastrectomy for ca	11 5	175	300	650	10 9
H M	Total gastrectomy for ca	7 6	150	200	600	8 1
D E	Total gastrectomy for ca	8 4	180	250	900	8 6
E A	Total gastrectomy for ca	11 5	270	225	650	10 4
	Average		194			

TABLE VI
THE BLOOD LOSS DURING TRANSTHORACIC RESECTION FOR CANCER OF GASTRIC CARDIA

Patient	Operation	Hb	Blood	Surg	Blood	Hb Gm
		Gm				
		Per Cent	Loss	Est	Given	Per Cent
		Preop	Cc	Cc	at Op- eration	First Day Postop
L H	Transthoracic resection for ca cardia	12 0	450	450	1200	12 0
C K	Transthoracic resection for ca cardia	11 0	475	450	1200	8 6
	Average		463			

TABLE VII
THE BLOOD LOSS DURING RIGHT HEMICOLECTOMY FOR CANCER

Patient	Operation	Hb	Blood	Surg	Blood	Hb Gm
		Gm				
		Per Cent	Loss	Est	Given	Per Cent
		Preop	Cc	Cc	at Op- eration	First Day Postop
A W	Hemicolectomy for ca, with ileotransversostomy (anastomosis)	9 3	30	125	600	10 6
B K	Hemicolectomy for ca with ileotransversostomy (anastomosis)	9 9	160	300	650	10 8
A K	Hemicolectomy for ca, with ileotransversostomy (anastomosis)	11 0	230	350	600	10 8
A K	Hemicolectomy for ca with ileotransversostomy (anastomosis)	10 4	170	250	600	10 4
G S	Hemicolectomy and external ileocolostomy	9 0	125	300	600	7 5
	Average		143			
R G	Cecostomy	10 8	30	30	600	9 7

globin is below 60 per cent. Previous studies from this service⁵ have indicated that the best way to combat the anemia is to remove the cancer, after which the restoration of the blood picture to normal occurs spontaneously.

In each of the tables presented, a column is included to indicate the surgeon's estimate of the blood lost during each operation. During the early phase of the study, this estimate often was grossly inaccurate. It is altogether likely that other surgeons in other institutions without means to measure accurately the actual blood loss, would be equally wrong in their clinical evaluation of the bloody or bloodless character of a given procedure. However, accurate judgment is speedily acquired both during and after the operation, and this ability, once gained, can be a valuable part of the surgeon's training.

CANCER OF GASTRO-INTESTINAL TRACT

TABLE VIII

THE BLOOD LOSS DURING SIGMOIDECTOMY FOR CANCER

Patient	Operation	Hb Gm	Blood Loss	Surg Est	Blood Given at Op- eration	Hb Gm Per Cent First Day Postop
		Per Cent Preop	Cc	Cc		
S L	Resection of rectosigmoid and permanent colostomy	10 4	340	250	600	10 7
C H	Sigmoidectomy and Mikulicz colostomy	12 1	75	100	600	11 7
S R	Sigmoidectomy and Mikulicz colostomy	11 6	100	150	600	10 8
M K	Sigmoidectomy and Mikulicz colostomy	9 6	75	125	600	11 0
I P	Sigmoidectomy and Mikulicz colostomy	11 0	75	150	600	10 7
M P	Sigmoidectomy with end-to-end anastomosis	13 7	75	75	600	10 0
P P	Sigmoidectomy with end-to-end anastomosis	11 0	125	225	600	10 8
	Average		124			
A B	Colostomy	11 0	23	15	600	10 2
S S	Colostomy	6 6	10	15	600	9 3

TABLE IX

THE BLOOD LOSS DURING ABDOMINO PERINEAL RECTAL RESECTION FOR CANCER

Patient	Operation	Hb Gm	Blood Loss	Surg Est	Blood Given at Op- eration	Hb Gm Per Cent First Day Postop
		Per Cent Preop	Cc	Cc		
A S	Without colostomy and with preservation of sphincter	11 7	400	300	650	11 0
L R	Without colostomy and with preservation of sphincter	12 4	400	500	800	11 7
J L	Abdomino-perineal resection	11 5	535	700	600	9 9
P R	Abdomino perineal resection	11 0	735	1200	690	9 2
H H	Abdomino-perineal resection	11 0	325	400	650	10 8
A M	Abdomino-perineal resection	8 1	250	275	600	9 2
H M	Abdomino perineal resection	12 8	250	500	600	9 9
S S	Abdomino perineal resection	11 6	450	375	600	10 4
H S	Abdomino-perineal resection	11 7	350	450	600	12 3
	Average		411			
M S	Panhysterectomy, partial vaginectomy and abdomino perineal rectal resection with preservation of sphincter	6 9	900	1000	600	8 3

The values to the surgeon of having the blood loss measured for the operations he commonly performs are several (1) He achieves an accuracy in his clinical estimation of the amount of blood lost during any operation (2) This knowledge breeds a constant consciousness of the degree of blood loss so that he is not painfully surprised at unexpected shock or collapse Proper measures, therefore, are introduced in time to prevent such complications (3) The young surgical intern or resident is furnished with figures which he may use to compare with the blood loss sustained during his own procedure In no other way can he be so strongly impressed with his own skill or deficiency in the maintenance of hemostasis

CONCLUSIONS

1 The amount of blood lost in gastro-intestinal surgery is not excessive and is less than the average in a radical mastectomy The surgeon's initial estimate of the blood lost during an operation is not always accurate, but improves with experience gained in subsequent operations

2 The difference between the pre- and postoperative concentrations of hemoglobin cannot be used as an index of blood loss

3 It is important to ascertain the amount of blood shed during operation

in order not to give unnecessarily great amounts of fluid. This is especially true for elderly patients with cardiovascular insufficiency.

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ENTEROGENOUS CYSTS AT THE ILEOCECAL JUNCTION

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ENTEROGENOUS CYSTS have been described in many portions of the alimentary tract, and various theories have been developed to account for their origin in various localities. However, in this discussion we are concerned only with enterogenous cysts situated at the ileocecal junction. These cysts have been variously described as of diverticular origin and due to remnants of the vitelline duct. They are classified by McLanahan and Stone¹ as submucosal, intramuscular, subserosal, mesenteric and antimesenteric. These authors state that they are most common in the ileocecal region and least common in the rectum. It appears that there exist in the embryo numerous diverticula from which enterogenous cysts may develop. Their widespread distribution militates against the theory of development from an unobliterated omphalomesenteric duct. We may say that cysts arising from the vitelline duct resemble enterogenous cysts but are necessarily limited in distribution. Serial sections of human embryos have disclosed evidence of epithelial sequestration. This may possibly be the source of cyst formation in later life.² Diennan³ observes that cysts and diverticula are in reality different phases of the same process. They result from the growth of a bud or from the prolongation of epithelium which has pushed into the mesenchyme. The solid bud then becomes vacuolated and an opening into the intestine may result. In this case, it is a diverticulum. If no opening occurs, it becomes a cyst. The walls usually contain the elements of intestinal structure. It is unwise to speak of true and false cysts as they vary only in the proportions of different layers.

At this point, one might emphasize the fact that the typical cyst consists of muscularis, submucosa and mucosa. The mucosal epithelium may form a complete lining or may exist in patches and the epithelium may contain glands. It is usually of the columnar variety but may be of the low cuboidal type. The fluid contents are usually pale, or straw-colored, but may be mucoid in character and colorless.

DIAGNOSIS

The diagnosis of enterogenous cysts at the ileocecal junction is manifestly difficult and only by keeping the entity in mind can one possibly arrive at this diagnosis. Roentgenologic studies can be of little help except to show signs of compression, inasmuch as there is no connection with the lumen of the contiguous bowel. Cases have been reported at this location from birth to the age of 30 years predominantly in females. Hughes and Jones² have found that cysts of the last four inches of ileum usually are discovered in the

first year of life but cysts of the cecum are found either in the first six months of life or between the ages of 20 and 30. Given a case of a palpable mass in the right lower quadrant, particularly in a youngster, one must consider the possibility of enterogenous cyst in addition to intussusception, appendiceal abscess, regional ileitis, granuloma of the cecum, and possibly twisted ovarian cyst. In the end, the diagnosis will be made at the operating table.

SYMPTOMATOLOGY

The signs and symptoms may be of three varieties: 1. Those due to local pressure with obstruction to intestinal passage; 2. Pain due to tension within the cyst; 3. Those due to ulceration into a blood vessel with bleeding—this being a rare complication. Any or all of these factors may be present and productive of symptoms.

The presenting symptom is usually pain in the right lower quadrant. The pain may be constant and due only to the tenseness of the cyst or it may be of the intermittent type, due to partial or complete obstruction. There may very well be a constant and intermittent element to the pain. All the signs and symptoms of obstruction may be present, depending on when the patient has been seen. The physical examination will show a tense, globular mass in the right lower quadrant, tender to touch, and usually quite mobile. The mobility of the tumor is usually a striking feature and should make one suspicious of the proper diagnosis. Hughes and Jones, in a series of 34 cases, noted simple obstruction in 14 instances, intussusception in six cases, and volvulus in three cases.

TREATMENT

The most interesting phase of this entity is the treatment. Inasmuch as the patient usually presents signs and symptoms of an acute abdomen, operative treatment is carried out in most cases as an emergency measure. In most instances the surgeon is confronted with a very sick child, often with some degree of obstruction, and the procedure of choice in such instances is debatable. As a matter of fact, the choice of the proper procedure forms the "*raison d'être*" of this paper.

The operative treatment resolves itself into four procedures: 1. Intestinal resection, with anastomosis; 2. Enucleation of the cyst; 3. Evacuation of the cyst; 4. Marsupialization of the cyst.

1. *Intestinal Resection, with Anastomosis*—This procedure is a major procedure to be carried out in a desperately sick child, often in the presence of an intestinal obstruction. We must bear in mind, also, that it is being undertaken for a benign ailment, which, with more conservative treatment, could, at worst, result in a mucous fistula. There is no doubt that the procedure is curative but, perhaps, at a prohibitive price. Hughes and Jones report 14 cases of enterogenous cysts treated by intestinal resection, with 11 deaths and three recoveries. On the other hand, Pachman,¹ in a series of 15 cases treated by

resection, reports 11 recoveries and four deaths, or 26.7 per cent mortality—a remarkable record but still a high mortality rate

2 *Enucleation*—This is fraught with danger, inasmuch as the cyst is part and parcel of the intestinal wall and cannot be enucleated without opening into the intestinal wall. Opening into the large bowel in the presence of obstruction may easily result in a fatality. Hughes and Jones report a series of nine cases treated in this manner, with five successes and four failures. Drennan states, categorically, that in no case has enucleation been successful. If the cyst is of the intramural type, with which we are concerned, enucleation is manifestly a dangerous procedure.

3 *Evacuation*—Simple evacuation, or partial resection of the cyst, can only result in its refilling, with an unsuccessful result. One must keep in mind the possibility of leakage into the peritoneal cavity after such a procedure with resultant chemical and possibly bacterial peritonitis. Hughes and Jones report one fatality from this procedure.

4 *Marsupialization*—Inasmuch, as one is usually dealing with an acute and often desperate situation in a young child, the conscientious surgeon would choose the procedure that relieves the immediate symptoms, gives some hope of primary cure and, if not, will allow a more radical secondary procedure at a future time under more favorable circumstances. Thus, if the tense cyst is emptied of its contents (which should be sterile) the obstructing factor is immediately relieved. However, one must then fix the cyst wall to the abdominal wall, thus marsupializing it and allowing free drainage to the outside. Recovery is usually uneventful. Hughes and Jones report two cases with two recoveries, treated by this method but no mention is made of permanent recovery or persistence of a fistulous tract. Beekman⁸ reports a marsupialized case with secondary fistula which was ultimately closed. Pachman reports a series of two cysts at the ileocecal junction treated by marsupialization, with two recoveries.

The use of escharotics to try to obliterate the mucosal lining of the sac, and thus obviate a secondary procedure, does not seem to have been emphasized in the literature. We feel the most logical and least risky method of handling these cases, where at all possible, is marsupialization and subsequent treatment with escharotics. If the fistula fails to close, intestinal resection can always be carried out. At this time one has the obvious advantage of a good-risk patient.

Case Report—M. N., female, age six, was admitted to the Montefiore Hospital, May 1, 1941, with a 24-hour history of abdominal pain, intermittent in type, associated with emesis. Interrogation revealed the fact that on several occasions during the year previous to admission there had been several episodes of pain, which spontaneously were relieved. The past medical history was otherwise negative. The family history disclosed nothing of note.

Physical Examination—This disclosed an acutely ill child in evident pain. The abdomen was somewhat distended, peristalsis was active. Palpation in the right lower quadrant revealed a tense, highly mobile, tender mass about the size of a small orange. Immediate operation was performed.

Operation—The peritoneal cavity was opened through a right rectus incision, and disclosed a mass, cystic in nature and the size of a small orange, at the ileocecal junction, which was apparently producing a partial obstruction of the small bowel. An attempt was made to obtain a plane of cleavage and enucleate the cyst, but it was found to be intrinsically a part of the bowel wall and this could not be done. The cyst was opened and a large amount of mucoid material escaped. On inserting a finger into the lumen one could appreciate that it was not continuous with the bowel lumen. It was decided to marsupialize the cyst and treat it with escharotic solutions later. The cyst wall was fixed to the peritoneum and fascia, and the layers of the abdominal wall were closed loosely around it. One strip of vaselined gauze was placed in the cavity of the cyst. Cultures from the cyst fluid were sterile.

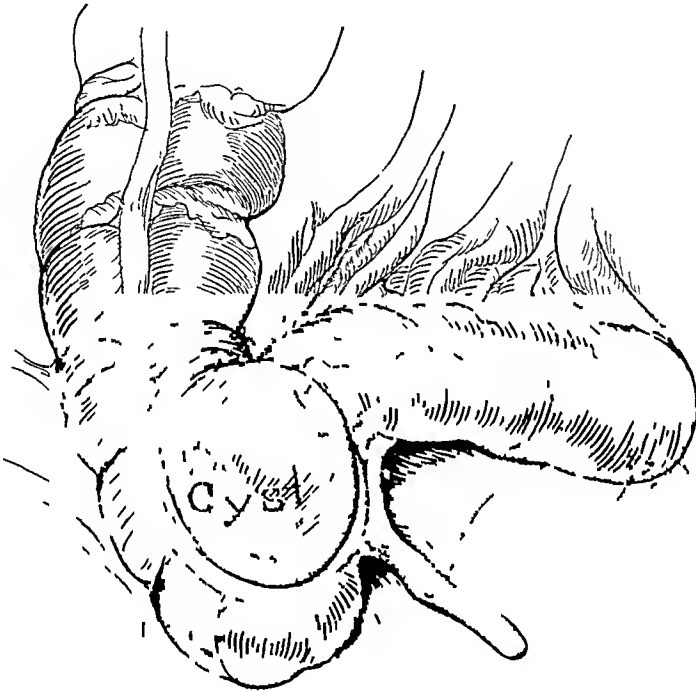


FIG. 1.—Drawing showing the gross appearance of the cyst at the ileocecal junction.

Postoperative Course—The patient's convalescence was uneventful, and she was discharged 15 days later with a draining mucous fistula.

Subsequent Course—One month postoperative, treatment with pure carbolic acid and alcohol was instituted, this was continued sporadically, at first weekly and then monthly. At one time sodium morrhuate was tried as the escharotic agent. The amount of drainage gradually lessened but a tract was still present. From time to time the tract would close over but would eventually open again. A lipiodol injection about eight months postoperative, disclosed a small sac, the size of a walnut, still present. Shortly after this (about nine months postoperatively) spontaneous closure resulted.

The child remained in good health until two years later, May 15, 1943, when she complained of pain in the right lower quadrant and a tender mass could be palpated in the scar. Incision and drainage revealed a moderate amount of chocolate-colored material, with no mucoid substance present. The culture was positive for staphylococcus. Drainage persisted for about three weeks and closure resulted. There has been no recurrence at this writing (eight months later). Apparently the mass was due to a collection of old blood, the source of which would be difficult to determine.

SUMMARY AND CONCLUSIONS

A review of the literature reveals the fact that enterogenous cysts at the ileocecal junction are of infrequent occurrence. Radical surgery in the treatment of this entity carries with it an unnecessarily prohibitive mortality and, in our opinion, should not be carried out unless a complication such as gangrenous bowel is present. Simple marsupialization, with subsequent escharotic treatment carries with it a fair chance of ultimate cure. Elective resection can always be carried out with much less risk to the patient.

An instance of ileocecal cyst in a female child, age six, has been presented. Treatment consisted of marsupialization plus escharotics. The result seems to have justified this conservative procedure.

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DIFFERENTIAL DIAGNOSIS OF CAUSES OF PAIN IN THE LOWER BACK ACCOMPANIED BY SCIATIC PAIN*†

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THE SYMPTOM OF BACKACHE with referred pain along the course of the sciatic nerve has for many years attracted the attention of orthopedic surgeons and industrial surgeons everywhere. Looking back at the evolution in the diagnosis of this condition over a period of 35 years, one cannot help but remember the old days when the diagnosis of "railroad spine" was made in those cases where an injury occurred at the onset of backache, which was not infrequently followed by sciatic pain. This diagnosis was due to the inability of the medical profession to comprehend the underlying pathologic changes which can happen, and which do happen in the lower back. Little effort had been made, judging from the literature, to assign the symptom of pain to any real lesion.

Goldthwaite¹ then propounded his theory of strain, subluxation, or disease of the sacro-iliac joint. As a result of his work much interest was aroused in the subject, and for a few years the literature was filled with the advocacy and defense of this theory. The next great step was made by the contribution of Willis,² who reported anomalies in 7 per cent of 748 anatomic specimens. He found marked variation in the normal anatomy of the lower spine, particularly at the lumbosacral junction. Willis called attention forcibly, and conclusively, to these variations in the mechanical structure which could account for many of the symptoms and combinations of symptoms exhibited in the lower back. These anatomic variations might also affect the emerging nerves and the ligaments supporting this portion of the spine. His findings rationalized certain conclusions made previously on a clinical basis regarding the causes of low back pain.

In 1916, I stated before the American Roentgenological Society that low back pain and sciatic pain were to be attributed more to strain of the ligaments of the low back than to any other one cause. I pointed out that all the components comprising this part of the anatomy, namely, the fascia, muscles, joints with cartilage and synovia, tendinous attachments, interlacing ligaments, all surround a bony canal through which the peripheral nerves course, that these structures were subject to the same diseases to which like structures in other parts of the body were vulnerable, that inflammatory reaction in these structures was much more prevalent than in like structures in other parts of the body where there was less cause for strain, and that infection, allergic reaction, gout and other forms of toxemia caused by sys-

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temic conditions could and did produce the same symptoms which in recent years have been ascribed to rupture of an intervertebral disk

If there is one place in the body where a fine differential diagnosis is necessary it is in the low back. Mechanically, the low back is structurally weak for the work it is required to do. It is the fulcrum on which every motion of the body is pivoted. It lies at the junction of a flexible with an inflexible part, namely, the lumbar spine with the sacrum and the ilia. As previously stated, the tissues which compose the low back are subject to the same ills as similar tissues elsewhere in the body. Moreover, the mechanical strain exerted on these tissues is much greater than elsewhere. In addition, more anatomic variations in structure are found in the lumbosacral junction than in any other location. All these factors contribute to making the low back an area where pain can occur with great suddenness and can be caused by various agents.

In the recent literature, neurosurgeons stand out preeminently as contributors to the subject of low back pain accompanied by so-called sciatica. Their approach has been mainly from the standpoint of root pressure from a ruptured intervertebral disk. To one who has been interested in the subject for more than 30 years, and has examined many hundreds of such cases, this viewpoint seems much too narrow. It is not the intention to contend that low back pain is not, or could not be caused by rupture of a disk, with pressure on the roots, but to point out that the same symptoms can be caused through disarrangement or inflammation of other structures. It seems strange that Schmorl³ who dissected more than 10,000 cadavers, found only two cases of traumatic rupture of the nucleus pulposus, whereas our surgeons have operated upon hundreds of cases for this condition in the last five years. Schmorl found various degrees of degeneration of the disk and ligaments in more than 15 per cent of all specimens. These degenerative changes around the lumbosacral joint were 7 per cent greater in men than in women, which would tend to indicate that heavy labor has an effect on the structures supporting the lower spine.

It is 30 years since I performed my first bone graft for immobilization of the lower spine. For 12 years I have made sections of the joints of this region in every case operated upon, and in every case pathologic changes were found in the cartilage of the joints, associated with varying degrees of inflammatory reaction in the capsules and ligaments adjacent to or extending from the joints. When one considers that the joints at the lumbosacral junction, for their size, carry approximately ten times the weight per square inch that the knee joints carry, and that the mechanical strain exerted by body weight thrusting downward and forward at the lumbosacral joints puts constant pressure on normally formed joints, it is easy to conceive that in abnormal joints this weight is transferred to the ligaments which, in turn are required to carry the strain. In either case the strain occurs not on the intervertebral disk in the low lumbar region, but on the ligaments and joints posterior to the spinal canal. In flexion, part of this weight is transferred

to the bodies of the vertebrae and the intervertebral disks, which act as a cushion and compress at the same time that the inferior articular facets of the fifth lumbar vertebra move upward on the superior articulations of the sacrum. The posterior ligaments are stretched as the articulations slide. If there is normal elasticity in the ligaments and the capsules of the joints, and the joints are smooth, this sliding motion can be made without discomfort. However, if the ligaments are degenerated and have lost their elasticity or if the joint surfaces are rough and surrounded by small exostoses at the attachment of the capsules and tendons, this motion can cause pain either from overstretching of the ligaments which are not able to withstand the strain put upon them, or by actually causing minute tears of this fibrous structure. Moreover, the joints can catch and lock, because the gliding motion is absent due to erosion.

Everyone is familiar with such occurrences in other joints which are degenerated or eroded. From the pathologic changes and symptoms which occur in other joints, especially the knees, which are much more easily examined, we know that swelling, locking and severe, sudden, sharp stabbing pain occurs. We can feel the crepitation and we can demonstrate the locking and immobility. From our pathologic studies, we know that the changes in the low lumbar joints do not vary from the lesions frequently found in the knee, elbow or hip. The swelling occurring as a result of ligamentous and joint injury is familiar to all practitioners of medicine. In the joints of the low back the pathologic changes do not differ from those of joints elsewhere in the body, except that swelling of the ligaments and the joint capsule can, and frequently does, narrow the exit of the nerves as they emerge from the spinal canal and foramen, the posterior wall of which is frequently formed by the anterior margin of the articular facets. The joint capsule of the articular facet lies immediately posterior to the nerve at its exit and forms part of the posterior wall of the foramen (Fig 1).

In a cross-section of the spine at the lumbosacral level (Fig 2) the normal lumbosacral joints lie at an angle of 45° to 60° to the anteroposterior plane of the body. There is, however, a great variation in the normal, and it is extremely difficult in many individual cases to judge from the roentgenograms whether these articulations furnish adequate support on one or both sides. What is normal for one person may not be considered normal for another. Roentgenograms should be taken from various angles before a decision is made whether the mechanical support between the vertebrae is adequate. One must take into consideration not only the anteroposterior but the horizontal plane of the joints because as the patient stands the lumbar curve is increased and a joint which looks almost perpendicular in the sitting position will become almost horizontal in the erect position depending upon the amount of tilt in the pelvis (lordosis) in standing. The more horizontal the articulation, the more strain is put upon the ligaments which support it and the low spine, in general in the flexed position. Instead

CAUSES OF PAIN IN LOWER BACK

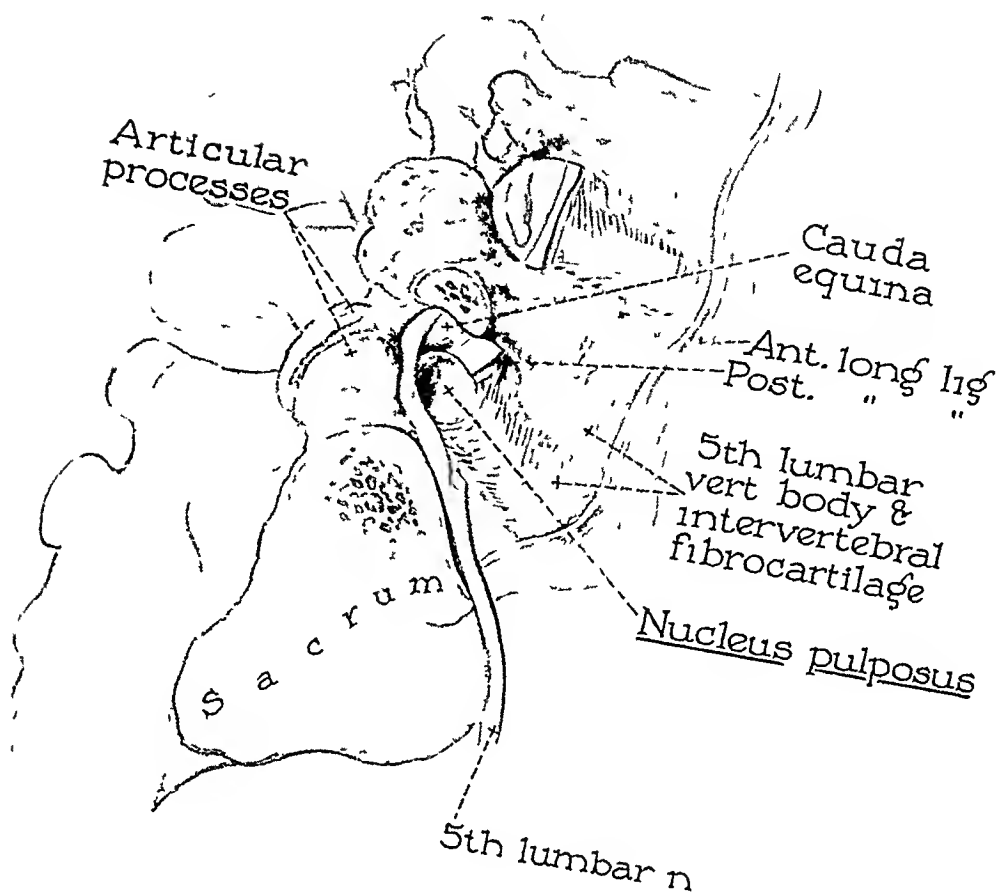


FIG 1

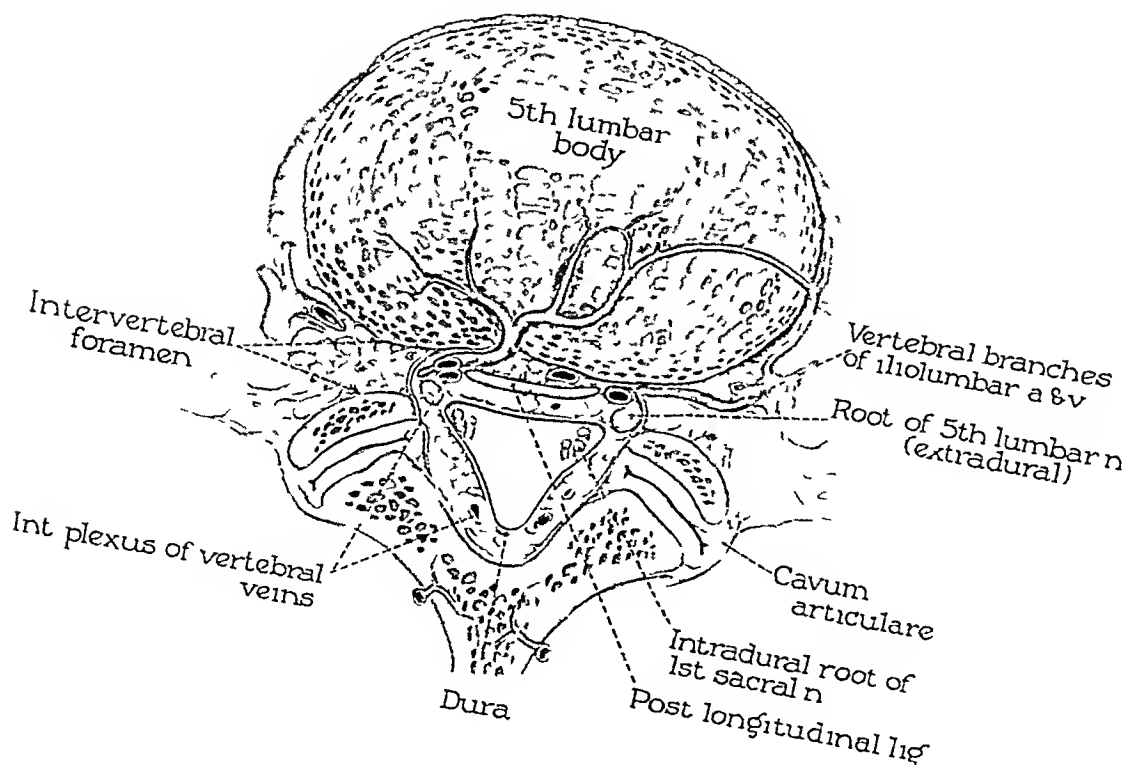


FIG 2

of the articular facets sliding up and down on each other, they slide from a posterior to an anterior position.

The angle of the joints may also vary on opposite sides. It is not infrequent to see in the same patient a perpendicular joint on one side and an oblique or horizontal joint on the other (tropism). In such a case the perpendicular joint will act as a pivot and the vertebra will rotate on the more or less horizontal joint, frequently producing pain in the more rigid perpendicular joint because of the rotary stresses.

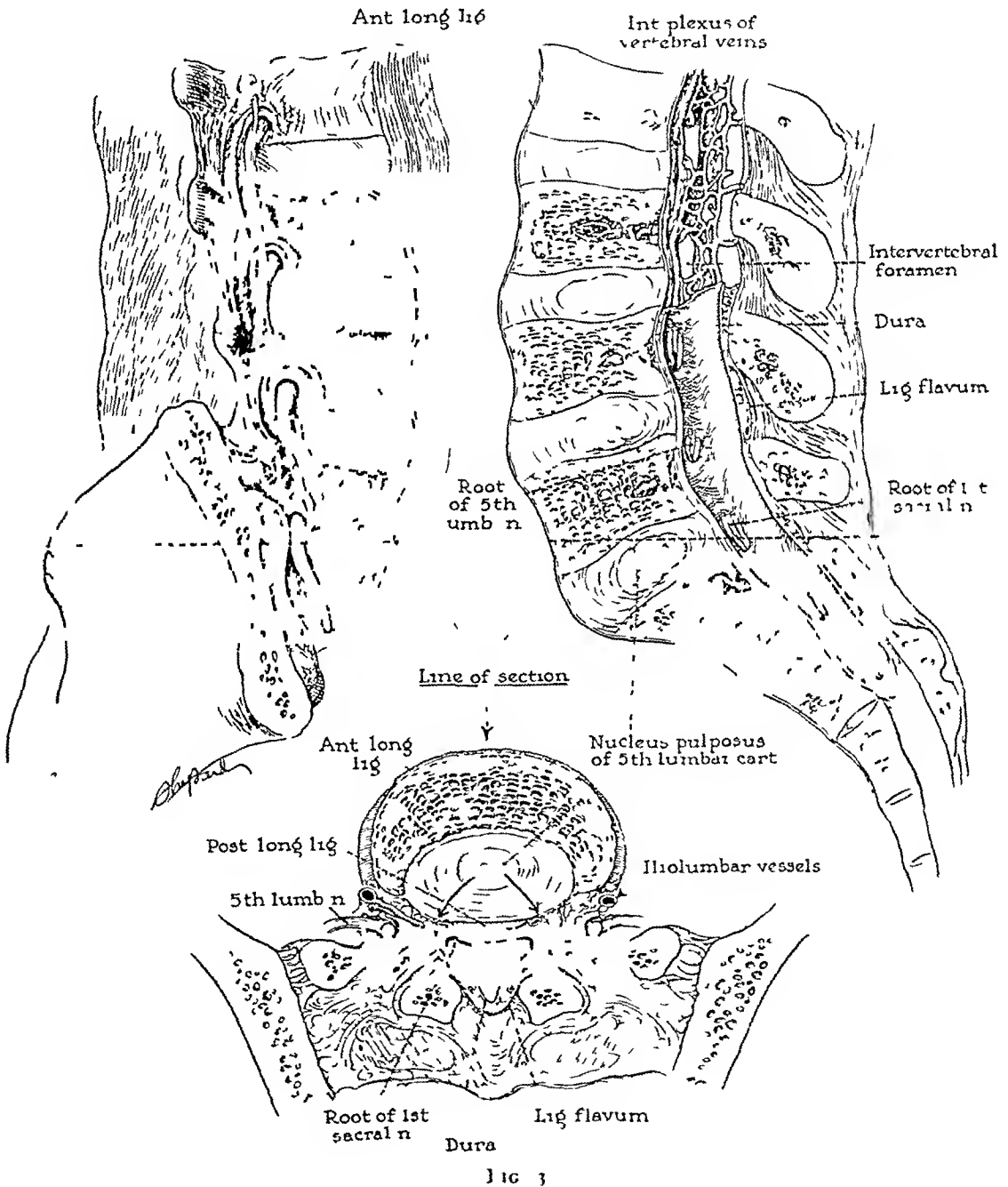
The integrity of motion depends on many structures as well as upon the plane and angle of the joints. The interspinous ligament, the joint capsules, the ligamentum flavum and the posterior longitudinal ligament must maintain the relative position of stability unless the articular processes are properly formed to accept the downward and forward thrust of the weight of the body in the upright or flexed position. The muscles are called into play to support and produce motions which are willed by the patient. Any interference with function of any of these tissues, or any pathologic changes existing, can cause pain in the back which may be followed by radiation down the leg, depending on whether swelling or inflammation occurs around or near the exit of a nerve.

Anatomic study of a cross-section at the fifth lumbar vertebra shows that the fifth lumbar nerve usually makes its exit from the dura just above the level of the fourth lumbar disk. This is the rule in each vertebra above this point. The nerve passes downward and outward to enter the foramen. At the point of exit at the fifth lumbar foramen it is well below the disk. It lies immediately in front of the anterior part of the fifth lumbar inferior facet or lumbosacral articulation, just in front of the anterior part of the joint capsule. The posterior longitudinal ligament, which forms the anterior boundary of the neural canal, extends three-fourths of the way across the width of the canal. Entering the vertebra just lateral to the longitudinal ligament is an internal plexus of veins. The posterior longitudinal ligament is a fibrous structure and is one of the sturdiest parts of the annulus. It blends with the annulus and forms the posterior wall. The nucleus pulposus is situated just a little anterior to the posterior edge of the vertebral body (Fig 3). The posterior and lateral wall of the neural canal is formed by the ligamentum flavum, which is attached to each vertebral arch above and below. The ligamentum flavum is cupped out at each intervertebral foramen where the nerves exit.

The measurements of these foramina in our specimens varied considerably. The average size was 7 Mm from front to back in both the fourth and fifth lumbar openings. The measurement between the pedicles in the fourth lumbar averaged 19 Mm, and between the pedicles of the fifth lumbar, 12 Mm. The size of the ganglion in both the fourth and fifth lumbar vertebrae averaged about 7 Mm (Fig 4). It will be seen by these measurements in ten fresh specimens that the distance between the pedicles of the fifth lumbar is considerably narrower than in the fourth, and that the

CAUSES OF PAIN IN LOWER BACK

diameter of the foramen is only slightly larger than the diameter of the ganglion. Inasmuch as the joint capsule and ligamentum flavum are continuous and almost inseparable by dissection at this point, it may readily be appreciated that any swelling or inflammation around the foramen could narrow the canal sufficiently to cause pressure upon the nerve root. Moreover, any inflammatory condition within the joint or any swelling or thickening of the ligamentum flavum in conjunction with the joint capsule could spread by continuity to the root of the nerve.



Personally, I have never seen a case with pain referred to the sciatic distribution, disappearance of reflexes, or neurologic symptoms referable to interference with nerve function, appear in less than seven days after injury to the low spine, excepting in two instances where there was severe

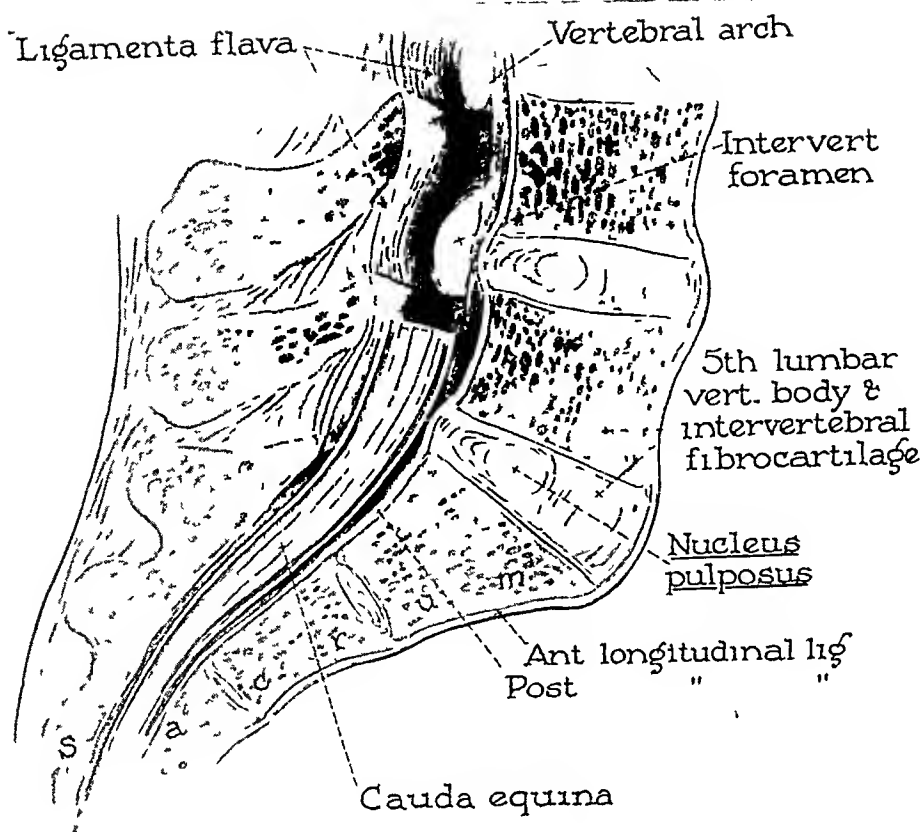


FIG 4



FIG 5

injury (Fig 5) In these two cases fracture and upward displacement of the ilium were present Both patients had exactly the same symptoms referable to the sciatic nerve I have seen similar symptoms many times in conjunction with low back pain where there was no roentgenologic evidence of pressure or injury to the nerve which exits from the low lumbar region

In fresh specimens we were able to inject the capsule of the fourth and fifth lumbar joints and narrow the exit of the nerve by as much as 2 Mm This narrowing was caused by mechanical distension and stretching of the capsule (Fig 6) The injection was made with thorotrast in order to obviate any possibility of the material breaking through the capsule without roentgenologic evidence of such leakage If it is possible to cause narrowing of 2 Mm from simple pressure within the joint it is quite evident that swelling within the joint plus thickening of the capsule by inflammation and/or the ligamentum flavum, could cause narrowing of the foramen to a point where serious pressure might be exerted on the nerve Schmorl¹ called attention to the fact that more than 15 per cent of his 10,000 cases showed degenerative process in the ligaments and tissues around the low spine, which means inelastic, thickened hardened tissues



FIG 6

We have previously demonstrated experimentally that arthritis with exostoses can be produced by trauma alone⁴ (Fig 7) This can be done repeatedly by weakening the support of a joint and causing it to bear cross-strain while the animal is active Exostoses form around the edge of the joint and the cartilage degenerates progressively due to the often repeated slight traumata constantly administered to the weakly supported joint These joints become roughened at the weight-bearing point and this roughness extends toward the edges of the joint The cartilage wears away at the point of greatest trauma and exostoses develop at the edge of the joint

These pathologic changes are the same as are commonly seen in the spines of individuals who have done heavy work over a long period of time When the joints become rough they do not glide normally The rough margins serve as friction surfaces to the worn and degenerated cartilage

This interference with smooth motion in the joint can cause catching and stabbing pain in the back, thereby creating muscle spasm and pain, exactly as seen in other joints similarly affected. We are all familiar with crepitation, thickening of the capsule, and swelling in the joints which can more easily be examined. There is no reason to suppose that the joints of the low lumbar spine differ in their pathologic reaction to various stimuli, such as trauma,



FIG 7

infection, toxemia and allergic reaction. These may all be contributing causes in the degenerative process which occurs at an area well known to be a point of great mechanical stress. The degenerative process, when it occurs in a disk, may cause marked narrowing of intervertebral space, associated with collapse of the disk and irritation of the surrounding soft parts and bone (Fig 8). When this happens, the annulus is pressed backward toward the canal and narrows the anteroposterior diameter of the canal. At the same time the foramen through which the nerve passes is diminished in size. Roentgenologic evidence of narrowing of the canal from front to back does not confirm the diagnosis of pressure on the canal or on its contents. That this irritation can be long-standing is shown in Figure 7 by the eburnation of the posterior lower third of the fifth lumbar vertebra. The area of osteosclerosis

CAUSES OF PAIN IN LOWER BACK

is more marked at the posterior part of the body where the greater weight is borne. Although the fourth lumbar intervertebral space is somewhat decreased there is no sclerosis, because the weight is borne across the diameter of the bone. It is only at the point of greatest pressure that the most marked reaction is seen.

The anteroposterior diameter of the canal is ample to accommodate such increased bulging from in front without actual pressure on the contents.



FIG 8



FIG 9

The exits and course of the nerves through the foramen also vary. In one of the ten fresh specimens there was a double outlet laterally for the fifth lumbar nerve, the nerve dividing into two branches before it made its exit from the spine (Fig 9). In another case the nerve divided just outside the foramen, one branch passed through the foramen, the other ran down under a broad ligament to its exit one-half-inch below that of the upper branch. The lower exit was extremely narrow and the nerve was held firmly by the overlying broad ligament (Fig 10-A). In another specimen (Fig 10-B) the foramen was very narrow on the side of entrance of the nerve and widened at the exit, its perpendicular diameter being about one-half its anteroposterior diameter (Fig 11).

It is quite apparent that variations in the path of the nerves are frequent not only in the foramen but at the exit from the foramen. Where the nerve is bound down, or the space through which it emerges is narrow, as in the specimens just described, a very little overstrain or inflammatory process in the ligaments through which the nerve makes its exit could cause definite



FIG 10

symptoms of pressure on the involved branch. It is true that rupture of a nucleus pulposus could cause pressure upon a nerve where it leaves the dura and passes down to the vertebra below to gain entrance to the foramen. At this point the nerve is pressed into the corners of the triangular canal laterally. The nucleus is wedged between the root and the dura and presses the root toward the lateral surface of the canal, while the dura is pressed toward the median line (Fig 12). If this happens the symptoms should be easily traceable to pressure upon this particular root and there should be no question about its localization on physical examination. The reflexes should be interfered with and the pain should be referred to the area supplied by this root. The pain should be consistently localized to one place and visual-

CAUSES OF PAIN IN LOWER BACK

ization (of which I do not approve) should show a filling defect outside the dura (Fig 13) If there is a rupture of the disk it can be plainly seen as a protruding mass outside the dura
If it is necessary to make a crucial incision through the annulus in order to disclose the nucleus then any existing symptoms are not due to a disk.



FIG 11



FIG 12

hidden or herniated It is always possible through an incision in the annulus to curet or otherwise bring out the material which forms the disk No incision should be made in the annulus at the time of exploration If there is a hernia of the disk it lies on the anterior surface of the canal between the dura and the annulus through which it has ruptured, further exploration is unnecessary Should the annulus be punctured by trauma which forces the disk out or by an instrument at the time of operation, this causes collapse of the intervertebral space If the center of the disk degenerates or is allowed to escape through rupture in the annulus the remainder of the disk may be forced backward into the canal as shown in Figure 8 Collapse of the disk with narrowing of the space between the vertebrae throws the articular facets between the vertebrae into a distorted position the angle may be

changed or they may override. This, in itself, puts strain on the joints, the capsules and the supporting ligaments, and will eventually produce traumatic inflammatory reaction which will necessitate furnishing support for the joints.

It may be asked why a certain number of patients are relieved of pain when they are operated upon for ruptured nucleus pulposus when no rupture has been found, only to have, later, a recurrence of symptoms. It is my

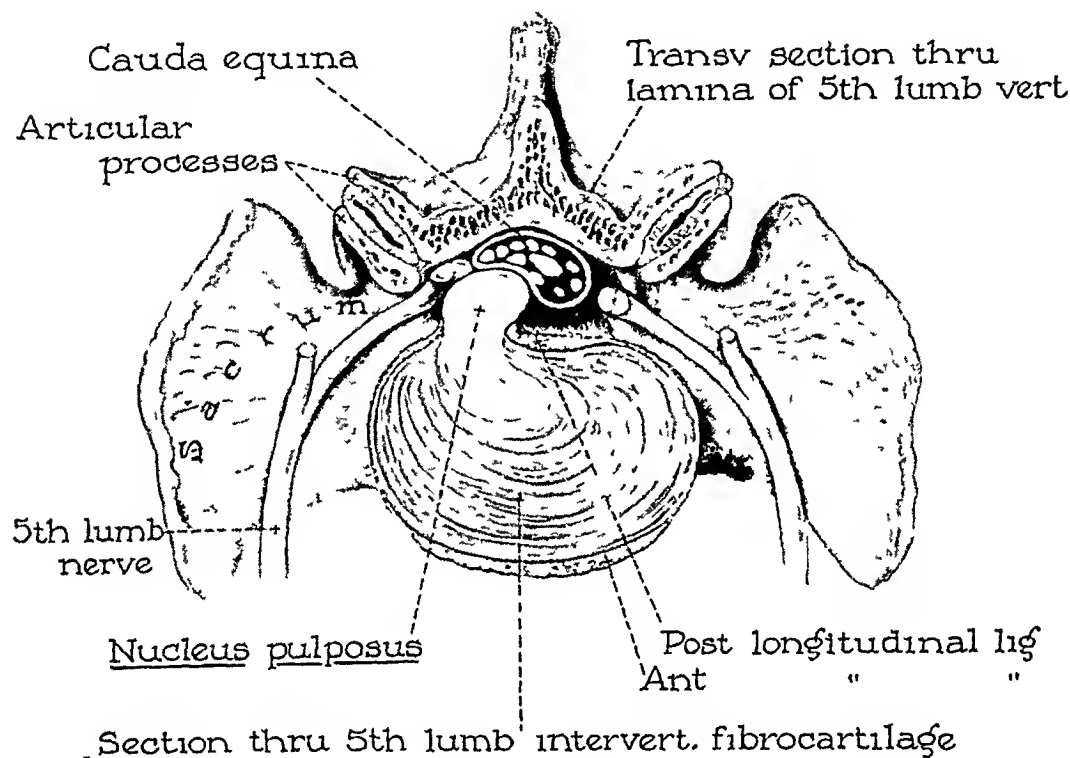


FIG 13

opinion that the reason lies in the fact that part of the lamina and the ligamentum flavum is removed, resulting in decompression of the probably thick and indurated parts of the joint which is continuous with the ligamentum flavum. Also, in the manipulation of operative procedure, joints which are locked because of roughness, muscle spasm and inelasticity of the ligaments, are relieved. I have seen many patients recover from their symptoms following rest in bed with traction, without any surgical procedure.

It is my opinion, therefore, that the reason for onset of pain after injury to the low back is, in a large number of cases, intimately connected with strain or other injury to the low lumbar ligaments and joints, associated with swelling and inflammation which, in turn, may be caused by minor strains of ligaments or joints already somewhat degenerated, or by lack of mechanical bony support at this point because of malformation.

There are many other contributing factors which cannot be discussed in a communication of this kind because they are not directly related to the

subject matter with which we are concerned. It is sufficient to say that the low back can be, and frequently is, the site of sudden severe pain followed by sciatic pain in days, weeks or months, which may be due to a combination of physiologic degeneration of the supporting tissues, infection, toxemia, arthritis, or a combination of one or more. These cases should not be subjected to operation on suspicion, they should be thoroughly investigated and an attempt made to establish a diagnosis. A large percentage of these patients get well with rest and traction and adequate treatment of the systemic condition which is a contributing factor. The promiscuous operation for and removal of intervertebral disks without definite evidence of root pressure is not justifiable until every other method of treatment has been reasonably tried.

I believe the spine should be permanently immobilized at the time of operation for a ruptured nucleus pulposus, whether or not the rupture is found. If the symptoms have been severe enough and have persisted for a sufficient length of time to warrant operation for their relief, then permanent relief should be afforded the patient by taking the strain off the degenerated tissues at the point from which the pain emanates. This can be done only by permanent immobilization.

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AN ANATOMIC STUDY OF THE LUMBOSACRAL REGION IN RELATION TO LOW BACK PAIN AND SCIATICA

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FOR MANY YEARS the syndrome of low back pain with associated sciatic nerve radiation has been a subject for investigation. The complex anatomy of the lumbosacral and sacro-iliac regions combined with numerous anatomic variations has complicated the problem of etiology of this clinical entity.

Two etiologic factors are now generally accepted as the basis for low back pain and sciatica. It has been conclusively shown that pain may arise in the joints, ligaments and muscles of the lumbosacral region and be referred throughout the distribution of the sciatic nerve. Pain may also arise from compression or irritation of the sciatic nerve at its roots. This may occur in the spinal canal in the intervertebral foramina where the nerve roots are in contact with the intervertebral joints or along the course of the nerve after its exit from the spinal canal.

This latter factor of compression of the nerve components has in recent years been emphasized by the widespread advocacy of the theory of herniation of the intervertebral disk into the spinal canal. It is a fact however that compression or irritation of the nerves may as readily take place in the intervertebral foramina where the nerve roots and ganglia are confined in a relatively smaller space. The anatomy and relationships of the sciatic nerve components to the structures composing the intervertebral foramina predispose to compression when pathologic changes occur in this region.

It was this fact which led us to take up the study of anatomic and pathologic changes in the lumbosacral joints and foramina. Ten unselected lumbosacral spines were obtained at autopsy and dissected to determine the variations in anatomy and pathology which may affect the spinal nerves as they course through the foramina. The fourth and fifth lumbar intervertebral foramina were studied to determine (1) The relative size of the nerves to the foramina, (2) the effect of swelling and effusion in the intervertebral joint capsules on the nerves and ganglia, and (3) the effect on the nerves of variations in ligamentous or osseous structures in the region of the foramina.

The fourth and fifth lumbar spinal nerves emerge obliquely from the spinal canal (Fig. 1). The nerve with its ganglion as it lies in the foramen is bounded above and below by the pedicles of the adjacent vertebrae anteriorly by the body of the vertebra and intervertebral disk posteriorly by the capsular ligamentum flavum. The capsular ligamentum flavum forms the

ANATOMY OF LUMBOSACRAL REGION

capsule and ligamentous support of the anterior portion of the intervertebral joints

Measurements were made of the fourth and fifth lumbar foramina and the respective nerves, to determine the relative size of each. The diameter measured between the vertebral pedicles was found to average 12 Mm in the fourth lumbar foramen and 19 Mm in the fifth. The largest diameter measured between the capsular ligamentum flavum posterior and the vertebral body anterior averaged 7 Mm in the fourth and fifth foramina.

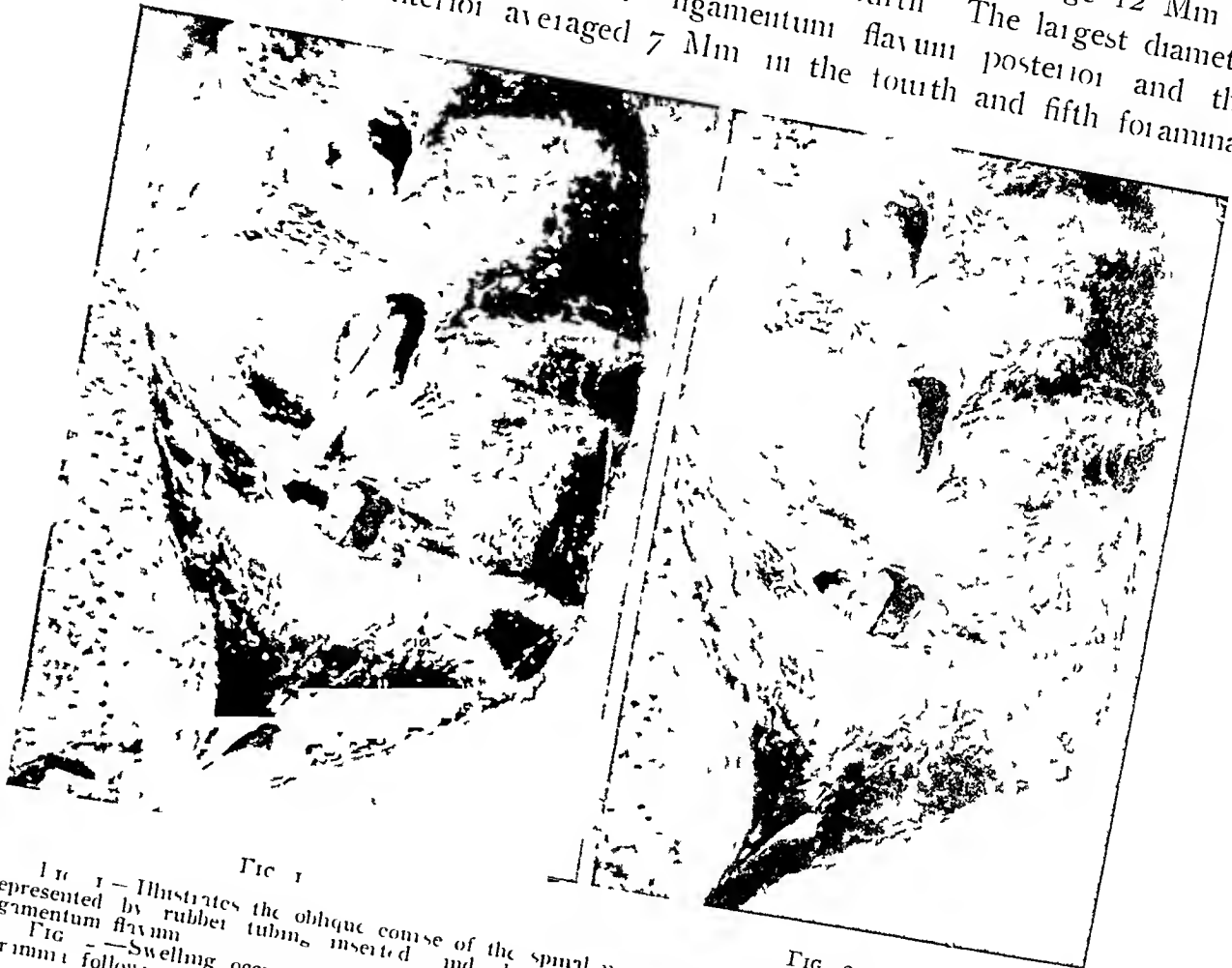


FIG 1

FIG 1—Illustrates the oblique course of the spinal nerve through the fourth lumbar foramen as represented by rubber tubing inserted and shows the relationship of the nerve to the capsular ligamentum flavum.

FIG 2

FIG 2—Swelling occurring in the capsular ligamentum flavum in the fourth and fifth lumbar foramina following injection.

Comparing the average size of the fourth and fifth nerves, which measured a fraction of a millimeter less than 7 Mm to the average anteroposterior diameter of the foramina, which measured 7 Mm, one is impressed by the intimate relationship of the nerve to the foramen. It may be concluded from these measurements that moderate swelling of the capsular ligamentum flavum can cause compression of the nerve in the foramen.

To determine the degree of distention or swelling of the intervertebral joint capsule necessary to compress the spinal nerves the joint capsules of the fourth and fifth lumbar joints were injected with radiopaque oil under pressure. Roentgenograms were made and measurements of the foramina were repeated.

Figure 2 illustrates the point where swelling of the capsular ligamentum flavum was most marked. The anteroposterior diameter of the foramina was reduced from an average of 7 Mm to an average of 5 Mm in the 40 joints injected. Roentgenograms made before and after injection clearly show the distention of the joint capsule and protrusion of the ligamentum flavum into the foramen (Fig 3). This distention took place regularly at a point intimately in contact with the ganglion of the spinal nerve.

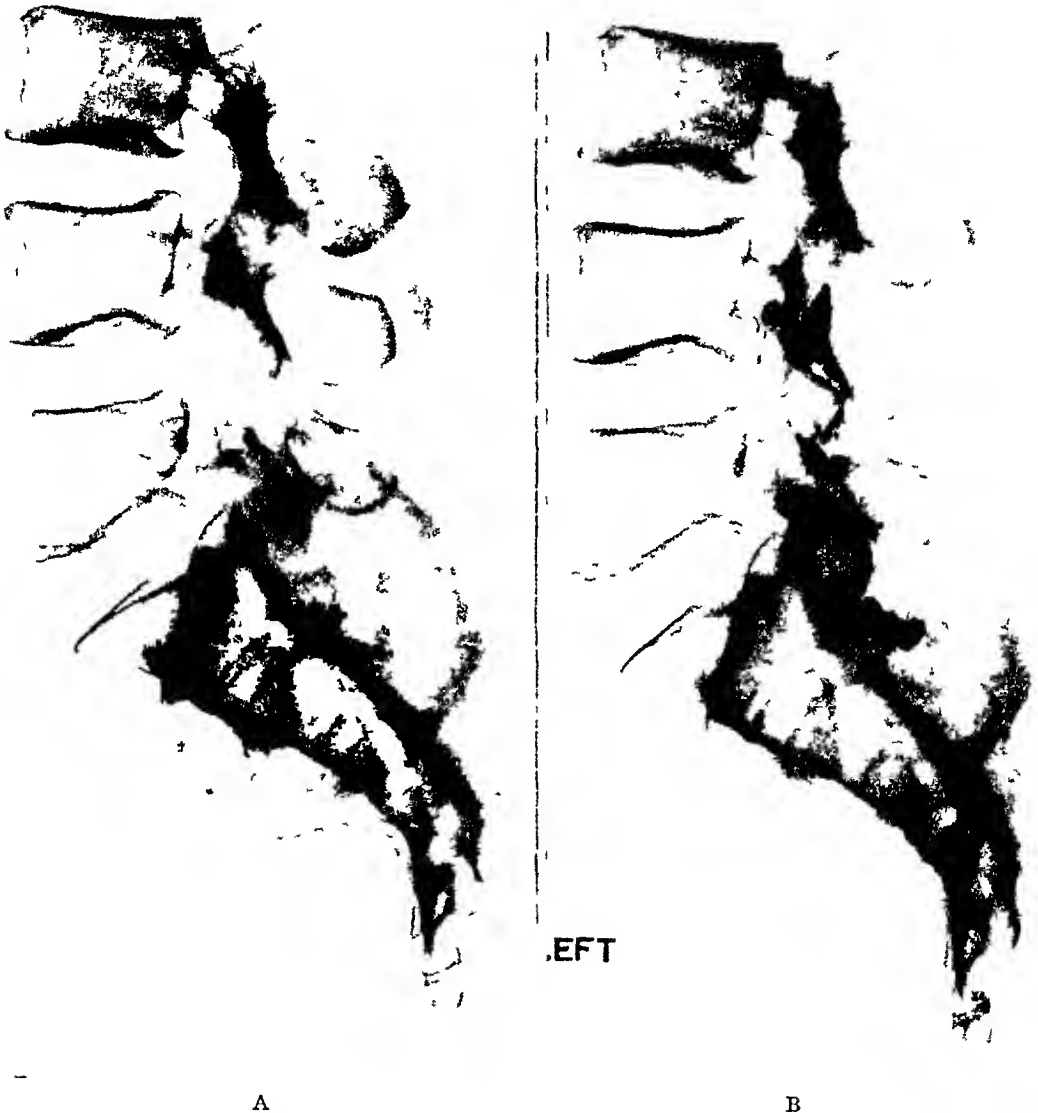


FIG 3—A and B Demonstration of radiopaque oil producing protrusion of the joint capsule into the fifth lumbar foramen before and after injection

Many anatomic variations have been reported in the lumbosacral region. In our series of spines a number of anatomic and pathologic variations were found. Four main pathologic processes were noted which produced compression of the spinal nerves in the intervertebral foramina or of closely related structures: (1) Posterior lipping or spur formation of the vertebral bodies at the foramen, (2) anomalies of the vertebral bodies, particularly

the first sacral, (3) degeneration of the disk substance, with collapse of the intervertebral space, and (4) variations in the ligamentous structures at the exit of the nerves from the spine

Posterioripping of the fifth lumbar vertebra occurred in four specimens. In each case the osteophyte formations were located in the foramina and produced narrowing of the anteroposterior diameter. All cases were associated with moderate to severe degenerative changes in the disk substance. Compression of the nerve was evident in two of the spines (Refer to Magnuson's article, Fig 8, p 887)

Anomalies of the first sacral vertebra were found in two spines. Spur formation on the posterior surface of the vertebra with impingement on the nerve at the exit from the foramen was noted in one case. A deep sulcus formed by the body and transverse process of the first sacral vertebra confined the fifth lumbar spinal nerve in the second case. The nerve was bent sharply at the point of exit from the foramen, and was bound tightly into the sulcus by firm ligamentous strands. Compression of the nerve in each case was only moderate (Refer to Magnuson's article, Fig 11, p 889)

Degenerative changes in the disk substance between the fifth lumbar and the first sacral vertebrae (Fig 4) were a prominent finding in this series of spines, occurring in four cases. Collapse of the intervertebral disk, without protrusion into the spinal canal, produced the most marked narrowing of the fifth lumbar foramen with compression of the nerve. Extreme sclerosis of the involved vertebral bodies with marginal lippings was a prominent feature in the pathology. Figure 9 of Magnuson's article, p 887, illustrates the marked reduction in the size of the foramen that takes place with collapse of the disk substance, particularly the distance between the pedicles.

The ligaments which join the fifth lumbar vertebra with the first sacral vertebra are subject to great variation, as was confirmed by our series of spines. In three cases it was noted that one ligament connected the transverse process of the fifth with the body of the fifth and the first sacral vertebrae. This ligament lay directly over the intervertebral foramen at the exit of the fifth lumbar nerve. The extent to which the ligament was



FIG 4—Comparison of normal vertebral canal and disks, with extreme degeneration of the disk and sclerosis of the vertebral bodies

developed varied considerably (Refer to Magnuson's article, Fig 10, p 888). The ligaments in each case bound the nerve firmly to the body of the first sacral vertebra. Evidence of compression could not be demonstrated in the two similar cases.

Numerous other changes were found in this series of unselected spines, including advanced arthritic changes in the articular facets, anomalous facets, variations in the angle of articulation of the fifth lumbar and first sacral vertebrae, and irregularities of the contour of the spinal canal. None of these anatomic variations produced compression of the spinal nerves.

It is of interest to note that although advanced degeneration of the disk substance was present in four cases, there was no rupture of the annulus fibrosus with protrusion of the disk into the canal. Compression of the cauda equina was not demonstrated in any specimen.

SUMMARY

A series of ten unpreserved autopsy spines were dissected to determine the factors which may produce compression or irritation of the spinal nerves in the intervertebral foramina.

By injection of oil into the joints of the fourth and fifth lumbar vertebrae sufficient swelling was produced in the capsular ligamentum flavum to compress the spinal nerves in the foramina.

Four anatomic and pathologic factors produced compression of the spinal nerves in the spines of this series: (1) Posterior tipping of the vertebral bodies, (2) anomalies of the first sacral body, (3) narrowing of the intervertebral foramen due to collapse of the disk, and (4) variations in ligamentous structures adjacent to the fifth lumbar foramen.

CHRONIC SPINAL EPIDURAL GRANULOMA*

REPORT OF TWO CASES

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CHRONIC SPINAL EPIDURAL GRANULOMA is a condition that occurs infrequently and is associated with acute epidural spinal abscesses, for both may have a common etiology. There were only 88 of these cases reported between 1855 to 1937, as reviewed in the literature by Ira Cohen,¹ in 1938. At that time he reported seven cases, five of acute epidural suppuration, and two of granulomata. Watts and Mintz² in 1931, reported four cases of chronic spinal epidural granulomata. No definite etiologic factors have been established in the cases of chronic spinal granuloma, tuberculosis and syphilis excluded, but certain conditions have existed in the body prior to the onset of neurologic findings of cord compression. These various conditions include a carbuncle of the neck, sepsis of the hand, traumatic back injury, perirectal infection, and convalescence from typhoid fever. In other cases no history of infection was ever present.

We are reporting two cases of chronic spinal epidural granuloma. In the first case there was a history of a draining perineal abscess which had existed one and one-half years before the onset of the symptoms of spinal cord involvement. There was no other history of illness for many years which could account for the findings at operation. Extension of pus from the kidney to the thoracic spinal cord probably was by lymphogenous or hematogenous route.

In the second case, the patient was operated upon at this hospital for an osteomyelitis of the squamous portion of the right temporal bone. This condition came to Surgery, November 13, 1941, and the patient's first neurologic symptoms were noticed April 19, 1943, a time interval of about one and one-half years. The patient stated that he had been perfectly well during the year and one-half-period, and had suffered from no illnesses.

Case 1—L. M. B., male, age 47, was admitted to the Neurologic Service, November 23, 1942, with a tentative diagnosis of spinal cord tumor or multiple sclerosis. He gave a history of having a perinephritic abscess in 1938, which drained for two or three months, and from which he had fully recovered. His first neurologic symptoms were low dorsal back pain with costal radiation, exaggerated by coughing and sneezing,

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which began in April, 1940. There was no evidence of sepsis at this time. The patient was then treated with short-wave therapy to the back, and his pain disappeared after three months treatment. In August, 1940, the patient noticed that he had trouble in keeping his footing while walking on rough ground or going up stairs. He gradually developed weakness of both lower extremities and tendency to a spastic gait. He was admitted to another hospital in September, 1940. At that time the neurologic findings showed a sensory level at about the 10th dorsal segment. The deep reflexes in the legs were increased and the Romberg sign was positive. Queckenstedt's test was positive for a complete subarachnoid block. Lipiodol visualization of the spinal cord revealed an extensive filling defect at the 12th dorsal vertebra. A laminectomy was performed at this level, and no gross pathology of the cord or vertebra was found. A tumor higher in the thoracic region was suspected because of the sensory level. Under fluoroscopic examination, and in the Trendelenburg position, the lipiodol ran freely through the subarachnoid space into the cervical region. It was the opinion of the neurosurgeon that a tumor of the higher thoracic region was not present because of an absence of obstruction. The patient was later seen by a neurologist, and a gastric analysis taken with histamine revealed an absence of free hydrochloric acid. The blood picture was essentially normal.

The patient was put on thiamine chloride hypodermically and orally given massive doses of reticulogen, and dilute hydrochloric acid, as well as a high protein and high vitamin diet. He responded rather well, however, he still had some weakness of the lower extremities. The impression at this time was that the patient had a multiple sclerosis. There was no bladder disturbance noted, but the patient did have some loss of erection. In December, 1940, the patient caught a cold and he noticed the weakness of the lower extremities to be more marked. He was again examined. The gastric achylia was again found with a normal blood picture. The patient was given liver extract intramuscularly, thiamine chloride hypodermically and orally, and quinine, grains five, three times a day. He responded very well at this time to this regimen so that, in March, 1941, he was able to return to his legal work and was walking with no discomfort or weakness of the extremities. The patient stopped his medication of his own volition at the end of 1941. In March, 1942, he noticed that he was experiencing difficulty in walking and that his feet felt heavy. He resorted to his former therapy, but there was no response this time, and he was soon confined to a wheel-chair. In April, 1942, he had a complete paraplegia of his lower extremities. He entered our hospital November 23, 1942, and, on examination, it was found he had a complete paralysis of the lower extremities and of the trunk below the level of the 10th dorsal segment, shown by positive Beevor's sign. Occasionally, on passive movement a localized hypertonicity occurred in the lower extremities, hyperextension of the great toes, and an involuntary flexion of the legs. At other times there was no great hypertonicity. The Achilles jerks were obtainable and were about equal perhaps the right a little greater than the left. The same was true of the knee jerks. There was no ankle clonus and no knee clonus. There was no motor disturbance in the upper extremities and the reflexes were normal. The plantar reflexes were absent, as well as the cremasterics and abdominals. No pathologic reflexes could be elicited. There was loss of sensation to touch at about the level of the 8th dorsal segment a little higher on the right than on the left side. On the left side the diminution to all the sensations of heat cold and pain were less over the sacral areas than any other area. The motor cranial nerves were normal and fundoscopic examination was negative. Queckenstedt's test was positive again. Examination of the spinal fluid was as follows: Clear and colorless, positive Ross-Jones, nine cells per cm., Wasseimann negative, and the Lange colloidal gold curve 0000112212. Total protein 65 mg. Gastric achylia was present, with a normal blood picture. There was no tenderness of the spine over the dorsal vertebrae. The impression was that the patient had a transverse lesion of the spinal cord extending

SPINAL EPIDURAL GRANULOMA

up to the level of the 6th dorsal vertebra probably due to compression, and a laminectomy was indicated

Operation—January 27, 1943 Laminectomy disclosed beneath the thoracic vertebrae (6th, 7th, 8th, 9th and 10th) a dense mass of tissue encircling the cord, and had to be removed with the ronguers, using considerable force The tissue was avascular, and when the dura was opened the exposed spinal cord was devoid of some of the blood supply and appeared yellowish-gray rather than normal pinkish-gray in color A catheter, passed from eight to ten centimeters superiorly and anteriorly from the operative field in the subdural space, met with no interference

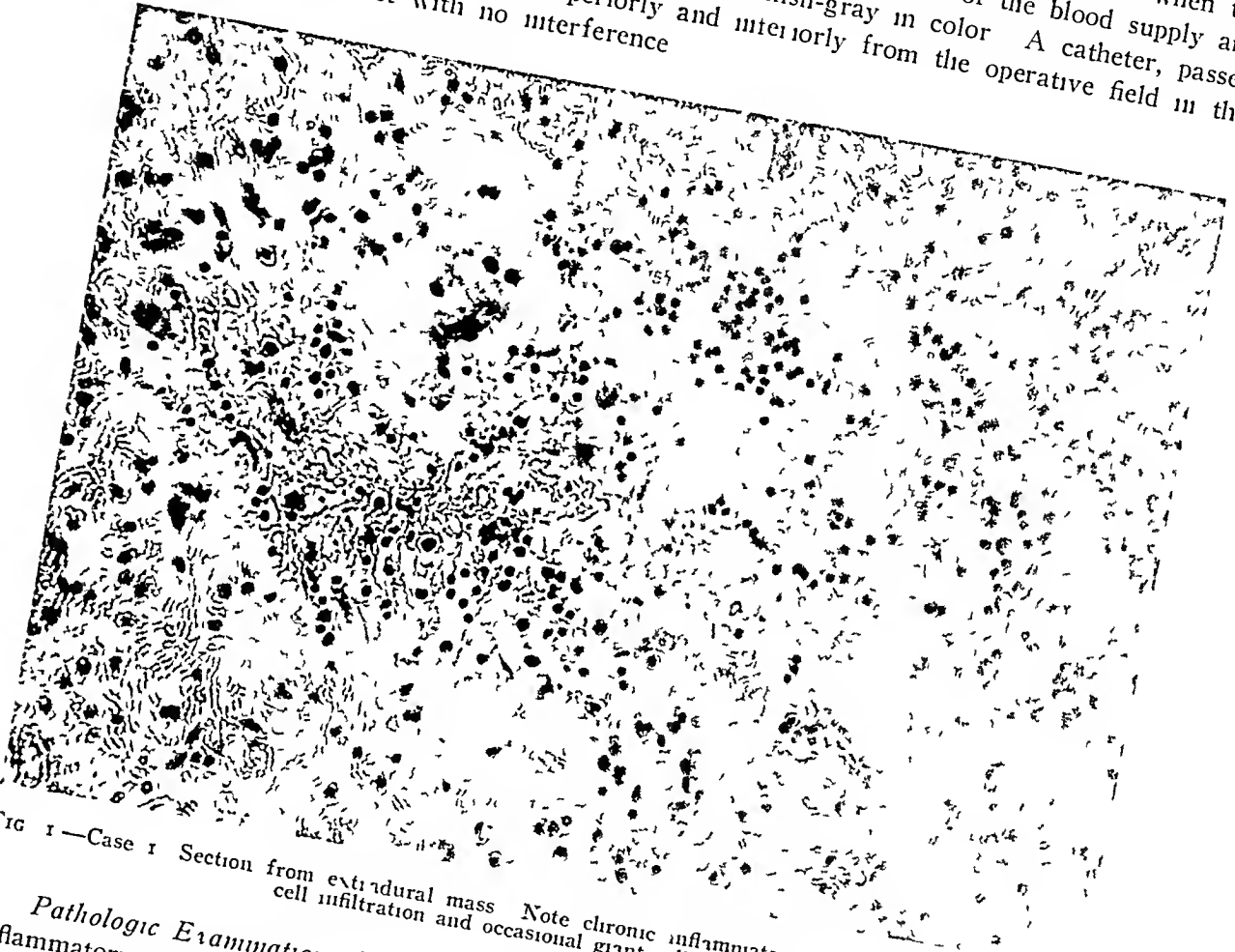


FIG 1—Case 1 Section from extradural mass Note chronic inflammatory cell infiltration and occasional giant cell ($\times 300$) tissue with diffuse round

Pathologic Examination Sections of the material submitted revealed an organized inflammatory exudate, in most instances completely organized and fibrosed There was much granulation tissue made up of newly-formed blood vessels and inflammatory cells of all types, round cells and mononuclear cells predominating, there were a few polymorphonuclear cells There were large masses of macrophage cells containing pigment and debris A dense scar surrounded these areas *Pathologic Diagnosis* Organized and fibrosed inflammatory tissue

Three or four days after the second laminectomy, the patient began to move his toes and flex his ankles, slightly Physiotherapy management was instituted ten days following surgery, and within two weeks the patient was able to lift both legs from a sitting position Two months after discharge from the hospital the patient wrote that he was able to walk with the use of a cane and could walk up and down the stairs Recently, the patient visited us at the hospital, and his gait was almost normal

Case 2—R E L, male, age 65, was readmitted to our Neurologic Service, August 5, 1943, with a tentative diagnosis of spinal cord tumor He gave a history of having been operated upon here, November 13, 1941, for osteomyelitis of the skull, involving

the posterosuperior portion of the squamous part of the right temporal bone. A stilted abscess delayed the healing of the wound for a few weeks but it was completely healed when the patient was discharged from the hospital. He was asymptomatic until April, 1943, when he began to notice some weakness in the lower extremities, associated with paresthesia. He had low dorsal back pain with costal radiation. He entered a private hospital, in July 1943, and remained there for three weeks. During this period of hospitalization his legs became weaker, until he became totally paralyzed in the lower extremities. He had loss of sphincter control of the bladder and rectum.

Physical Examination It was found that he had a complete paralysis of both lower extremities. There was a loss of sensation to touch slightly above the nipple on the left side and just below the nipple on the right. A complete flaccid paraplegia was present, with loss of all forms of sensation, including deep pressure pain in the lower extremities. The Babinski sign was negative, bilaterally. The patient had an indwelling catheter, and had a large decubitus ulcer in the sacral region. The motor cranial nerves were normal, and funduscopic examination was negative. Spinal fluid examination revealed a complete subarachnoid block with a total protein content of 120 mg. The fluid was xanthochromic, globulin was 4-plus Ross-Jones, ten cells per cm. Wassermann was negative and the Lange colloidal gold curve was 0000123332. There was no tenderness of the spine over the dorsal vertebrae. The impression was that the patient had a tumor of the spinal cord at the level of the 4th dorsal vertebra. However, since admission, the patient had been passing tarry stools, and laboratory examinations were positive for occult blood and occasional blood cells. The patient admitted being given charcoal for a supposed stomach disorder prior to admission to the hospital, however, examinations, to rule out a malignancy, were completed, and roentgenograms of the spine, skull, chest, pelvis and G. I. series were negative. The patient took a turn for the worse and, on September 10, 1943, he became critically ill, and died September 17, 1943, no surgery having been undertaken.

Autopsy—Longitudinal section of the dura disclosed several irregular areas of thickening and fibrosis of the dura at the level of the 4th to the 6th dorsal spine. The thickenings were in close apposition to the spinal cord, and resulted in compression of the cord itself. Section of the spinal cord produced an exudation of gelatinous, yellowish-white material from the parenchyma of the spinal cord. There was evidence of pressure liquefaction necrosis of the nervous tissue of the spinal cord.

Pathologic Examination—Microscopic This revealed a granulomatous process with extensive fibrosis. There was diffuse infiltration of all types of leukocytes, round cells, plasma cells, eosinophils, mononuclear cells and an occasional giant cell. The reaction was quite diffuse, although in some areas there were aggregations around the blood vessels. There were no definite tubercles noted, and none of the specific yeast fungus organisms could be seen. The lesion is apparently nonspecific and was, apparently, that of chronic inflammatory granulomatous tissue.

DISCUSSION

The diagnosis and treatment of chronic spinal epidural granuloma is like that of any spinal cord tumor. One finds spinal cord compression symptoms and signs, increase of lymphocytes and protein in the spinal fluid in some cases, partial or complete spinal block, occasional tenderness over the spine in early cases, and the Lange colloidal gold curve indicative of some pathologic process, but not characteristic. Loss of early sphincter control may occur in some cases, while in others loss of erection may be manifested. Exaggerated tendon reflexes in the legs, ankle clonus, and Babinski signs have been found present. Lipiodol visualizations show a definite block in

some cases. At our hospital this procedure is not used, Davis, Haven and Stone³ stating that the use of lipiodol may cause an arachnoiditis of the spinal cord. In the first case reported, lipiodol examination was completed prior to the patient's admission to our hospital. It revealed an extensive filling defect at the 12th dorsal vertebra. Laminectomy had been performed elsewhere at this level, but no gross pathology of the cord or vertebra was found. Sensory level, however, at about the level of the 8th dorsal segment was present and indicated a transverse lesion of the spinal cord extending up to the level of the 6th dorsal vertebra, probably due to compression, however, the examiner was misled by the lipiodol running freely through the subarachnoid space when the patient was placed in the Trendelenburg position. We feel that a permanent sensory level is satisfactory neurologic evidence of cord compression, without the additional use of lipiodol visualization.

In the first case the presence of an achylia associated with the neurologic picture was probably incidental, the blood picture being normal. The patient responded well to liver extract and thiamine chloride and quinine, but when repeated, a year later, it had no effect on the patient's condition. He became completely paraplegic.

The time interval of the complete paraplegia to surgical intervention was from April, 1942, to January 27, 1943. The first neurologic symptoms began in April, 1940. Hence it was during a three-year period that the patient's pathologic process was present in the spinal cord. The results following surgery were quite remarkable, considering the time interval that the pathologic process was present and the presence of complete paraplegia for nine months. Of the majority of cases reported, surgical intervention has been completed within three to six months from the onset of the first neurologic symptoms, and results have been very good, however, epidural granulomata can be present for a period up to three years, and surgery can still benefit the patient.

Although epidural spinal granulomata are not common, neurologists and neurosurgeons should bear in mind that they do occur. All cases previously diagnosed as spinal cord tumors should have a careful history for any antecedent infection occurring in the body prior to the occurrence of the first neurologic symptoms. A probable diagnosis of chronic spinal epidural granuloma can sometimes be made, and the prognosis, then, as far as recovery from surgery is concerned, can be considered good.

CONCLUSIONS

Two cases of chronic, spinal epidural granuloma are reported. In the first case good results were obtained from surgery despite extensive involvement of the spinal cord by granulomatous tissue extending from the 6th to the 10th thoracic vertebrae inclusively. The second case was not operated upon, due to the patient's poor condition. A draining perineal abscess and an osteomyelitis of the right temporal bone of the skull, each occurring one and one-half years before the onset of the first neurologic symptoms of spinal

cord compression, can be considered as probable etiologic factors in these cases of chronic spinal epidural granulomata. Achylia with normal blood picture was an incidental finding in the first case. Lipiodol visualization can be misleading in the diagnosis of spinal epidural granuloma. The presence of a sensory level, although not equal on both sides of the body, is very suggestive of cord compression. Even though a chronic granuloma of the spinal canal has been present for three years, results from surgical removal can be quite successful.

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VENOGRAPHY ITS VALUE IN THE DIAGNOSIS AND MANAGEMENT OF VENOUS DISTURBANCES OF THE LOWER EXTREMITIES

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THE NUMEROUS CLINICAL PROBLEMS originating in venous disturbances of the lower extremities have made venography a frequent and valuable aid in our work at McCaw General Hospital. Cases requiring further diagnostic investigation and those cases which have been previously treated at other hospitals with the results deemed not suitable for return to duty, are eventually sent to a general hospital for final disposition. During the past eight months a surprisingly large number of interesting venous conditions of the lower extremities have been encountered and studied with the aid of venography. It is our purpose to present the characteristic features of the clinical case-groups encountered and to demonstrate their diagnostic and therapeutic significance.

The intra-arterial injection of sodium iodide for radiographic visualization of the main and collateral vessels was originally employed and described by Dr. Barney Brooks, in 1924. In recent years a fairly large group of investigators have contributed to the elaboration of venographic technic, the proper interpretation, and the applicability to the diagnosis and treatment of disease originating in the veins of the lower extremities. The technic which we have used is essentially that described in a previous publication with some simplification and modifications adopted as the result of an increasing experience.

TECHNIC

The patient is placed in the prone position on a Bucky table, with the limb extended, moderately abducted and the foot everted. The patient should be placed so that the leg lies approximately along the midline of the table. Under local anesthesia a vertical incision 1.5 cm. in length, is made about one centimeter posterior to the external malleolus. At this point a small terminal tributary of the external saphenous vein is readily isolated. A No. 19 transfusion cannula is tied into the vein. The three films, size 14 x 17 inches, are then placed in the following manner:

Film No. 1, wrapped in black paper only (not in a film exposure holder or cassette) is placed underneath the lower leg, its upper border slightly above the knee joint.

Film No 2, wrapped in black paper only, is placed underneath the upper leg—films Nos 1 and 2 should overlap for about two inches above the knee

Film No 3 is placed in a cassette in the Bucky tray, its center about underneath the hip socket. Films Nos 2 and 3 should overlap considerably at the upper thigh

The tube is elevated as far as the tube-stand permits (42 inches in our equipment). In a darkened room, with the filament lighted, the centration is so arranged as to cover all three films. A Luer-Lok syringe containing 30 cc of 35 per cent diodrast solution is attached to the cannula and 1 cc of solution is injected. If no major reaction is observed after a 15-second interval, the remaining 29 cc are injected during a period of 45 seconds. Immediately upon termination of injection, one exposure is made covering all three films. This technic will prove satisfactory in most cases.

In the case of very tall patients or where visualization of the external iliac vein is particularly desired, the following modification is recommended. The tube is centered so that both proximal films are well covered, and this position checked by an adhesive marker or a rider on the rail. The tube stand is now moved distally and a cone inserted, and centration so arranged as to cover the most distal film only. The upper two films are protected through the cone. The injection of the contrast fluid is now started and, after 15 cc have been injected, the film of the lower leg is exposed. The tube stand is then moved to its previously marked cranial position, the distal film and the cone are removed, while the injection of the contrast solution is continued. The exposure of the two remaining films is made upon termination of the injection.

The exposure data on our equipment (4-valve fully rectified Keleket unit) using technic No 1 are 100 Ma, 80 to 82 K V, $\frac{8}{10}$ to 1 second for the average patient. Using technic No 2, modify as follows 100 Ma, 78 to 80 K V, $\frac{6}{10}$ second for the lower leg, and about 82 K V, $\frac{8}{10}$ to 1 second for the upper leg and pelvis.

The considerable difference in the thickness of the limb over the calf and over the pelvic region is compensated for by the fact that intensifying screens are used over the pelvis while over the lower thigh and calf a non-screen technic is used. The films, simply wrapped in black paper, overlapping the film in the Bucky tray, do not interfere with proper exposure of the latter.

Fluoroscopic examination has been combined with radiography in the earlier studies. By increasing familiarity with roentgenologic technic and interpretation, the roentgenograms alone have proven satisfactory. Despite the fact that in many instances injections can be made directly into one of the dorsal veins of the foot or the distal end of the great saphenous vein, we have continued to use the "cut-down" procedure on the terminal branch of the short saphenous vein, in view of the fact that the tying of a cannula into the vein permits control at all times of the rate of injection and the positioning of the limb.

Despite the fact that we have encountered some variables in the pattern, we believe that the major features of the superficial, deep communicating veins and tributaries can be accurately determined under the constancy of

VENOGRAPHY



FIG 1—Normal Venogram (a) Great (internal) saphenous vein (b) Short (external) saphenous vein (c) Deep veins of lower leg (d) Popliteal vein (e) Femoral vein

FIG 2—Cauliflower like localized dilatation of communicating vein in typical location at the inner aspect of the knee (a), associated with severe varicose veins of the lower leg (b) Normal straight femoral vein (c) Patent straight great saphenous vein (d)

procedure. We have, therefore, felt it unnecessary to use the application of a tourniquet to force the venous return into the deep channels.

Normal Filling and Roentgenographic Visualization of the venous channels of the lower limb is illustrated in Figure 1. The important features are as follows:

- (1) The deep tributaries of the lower leg fuse to form the venae comites of the anterior and posterior tibial arteries; these venae comites, in turn, fuse to form the popliteal vein.
- (2) There is straight tubular filling of the popliteal and femoral veins, the latter continuing in the inguinal region as the straight tubular iliac vein.
- (3) The great saphenous vein carries return superficial venous drainage from the entire medial aspect of the extremity, finally emptying into the femoral vein at the fossa ovalis in the groin. The short external saphenous vein carries return superficial venous drainage from the outer aspect of the lower leg, and empties into the great saphenous vein in the popliteal region or directly into the popliteal vein.
- (4) Communicating veins exist in variable number between the superficial saphenous system and the deep veins in both the lower leg and thigh. The direction of flow normally is from superficial to deep.
- (5) Competency and prevention of reversal of flow in the communicating veins and superficial veins is maintained by valves (Figs. 15a and 15b), which may be seen at varying levels. If these valves are partially opened, one sees two fine lines converging to the center of the vein. External to these lines symmetrical bulges in the vein walls represent the perivalvular sinuses (Fig. 15c).

A possible variant in the superficial saphenous vein in the upper thigh region is that of replacement of a single great saphenous by duplication or triplication of the vessel in the thigh, the multiple vessels joining to form a single saphenous trunk just before entrance into the femoral vein at the fossa ovalis. This variant is well illustrated in Figure 3.

CLINICAL CASE-GROUPS

I—VARICOSE VEINS

At this General Hospital we have been confronted with problems of recurring or indefinite varicose vein pathology. These cases fall into two classes:

(a) Those cases which have been referred for further evaluation of deep vein status and then possible applicability to surgical ligation. It is generally agreed that in a fairly large percentage of cases the usual clinical tests for determination of the adequacy of the deep veins (Perthes test, Trendelenburg test, Ochsner-Mahoney tests) are all too frequently inconclusive, particularly if the superficial varicosities are large, tortuous and more or less sclerotic. It is, however, our experience that the use of venography with demonstration of an adequate deep venous return has enabled us to determine more accurately the suitability of severe cases of varicose veins for surgical ligation. Furthermore, in these cases of extensive superficial varicosities, we have been able to visualize the presence of extensive, dilated communicating veins, which unless properly obliterated, would be a possible cause for recurrence and recanalization of the varicosities. A common type of such a communication

is the so-called "cauliflower-like" dilatation of a communicating vein frequently encountered in the region of the inner aspect of the knee, and well demonstrated in Figure 2 and Figure 15 (f)

Case 1—A 34-year-old 2nd Lieutenant, was referred for disposition from an overseas Station Hospital because of extensive varicosities of the right leg of about three years duration, with development of superficial ulcerations on the inner aspect of the leg during the past six months. The report from the Station Hospital stated that the clinical tests indicated incompetency of the deep vein return. On examination, the two ulcers present and the surrounding area of chronic dermatitis of the skin was rather characteristic of varicose vein pathology. The varicosities of the leg were very prominent, tortuous, and almost sclerotic. *On performance of the usual clinical tests for deep vein competency, the superficial varicosities did not empty satisfactorily. Venography was performed and indicated an adequate deep vein return* (Fig 2). Surgical ligation was performed, including a large cauliflower-like communicating vein, with an excellent clinical result. The ulcers were healed in six weeks, and the officer has now been returned to full duty.

(b) Those cases which have been operated upon previously, with subsequent recurrence of varicosities and their complications. It is admitted that even under the most ideal conditions there is still a fairly high rate of recurrence after surgical ligation and retrograde sclerosis therapy. We have performed venographic examination in all such cases sent in because of recurrences, and in almost every case we are able to visualize a communicating vein, usually in the mid thigh which permitted "shunting" from the femoral vein to the lower segment of the great saphenous vein (Figs 5 and 6), which apparently was responsible for recanalization of the saphenous and reestablishment of varicosities considered to have been obliterated. In one of these cases, one of these communicating veins in the lower leg had become widely dilated to "venous-lake" proportion and had been responsible for recurrent breakdown of soft tissue and chronic ulceration (Fig 4). It was a relatively simple procedure to surgically obliterate the faulty communicating vein, as demonstrated venographically, with excellent clinical results.

Case 2—A 23-year-old Private, had been operated upon seven months previously, with high saphenous ligation and retrograde injection of sclerosing solution. He was admitted here with a complete recurrence of varicosities of the lower leg and considerable weeping dermatitis of the lower leg. Venography demonstrated a direct communication from the femoral vein to the saphenous vein at about the mid thigh. Proximal to this point

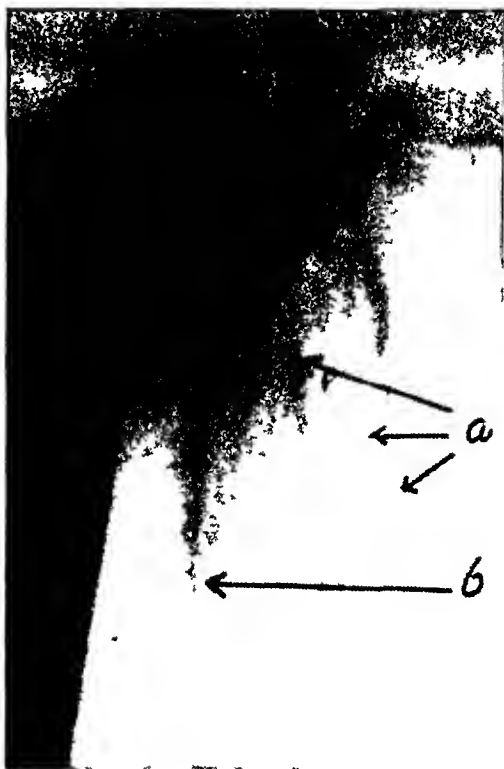


FIG 3—Normal Variant. Triplex of great saphenous vein (a) Femoral vein (b)



FIG 4—Surgical ligation of saphenous vein for varicose veins, with satisfactory obliteration of the saphenous vein, but failure to obtain cure. Large recurrent leg ulcer at the site of a markedly dilated tortuous communicating vein (a) which had not been obliterated. Subsequent ligation of the communicating vein, revealed by venography, resulted in prompt healing of the ulcer.

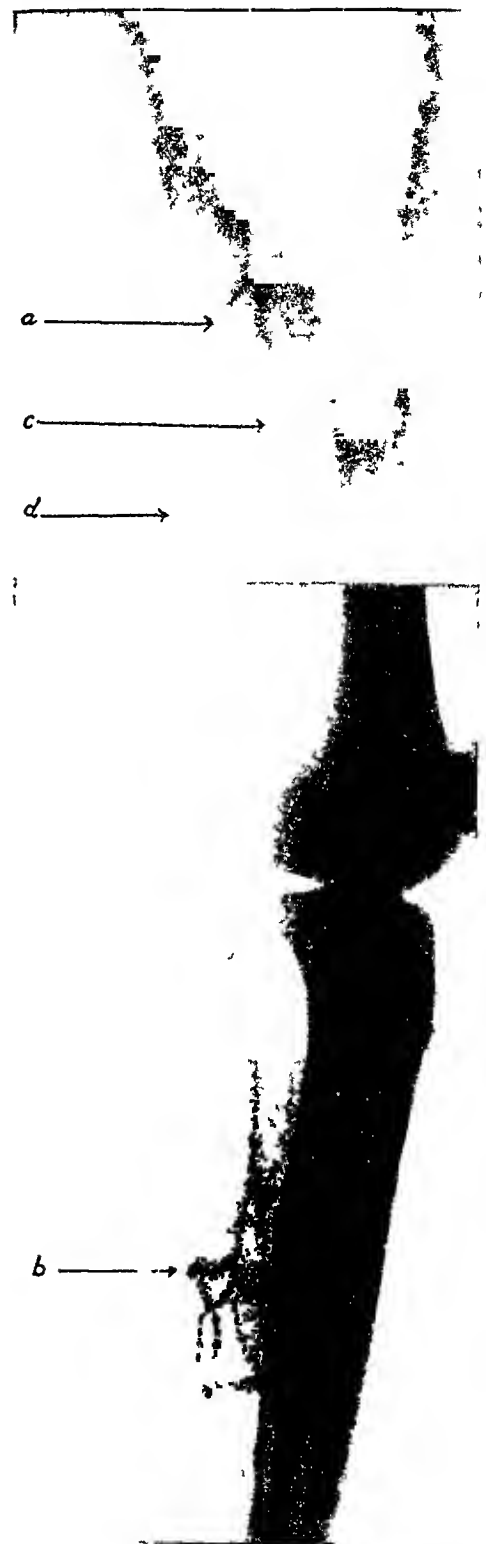


FIG 5—Recurrence of Varicose Veins Following Ligation of Great Saphenous Vein. Shunting of blood from femoral (c), to saphenous system (d), through a communicating branch (a) at the upper thigh. Varicosities (b) of the lower leg.

VENOGRAPHY



Fig 6

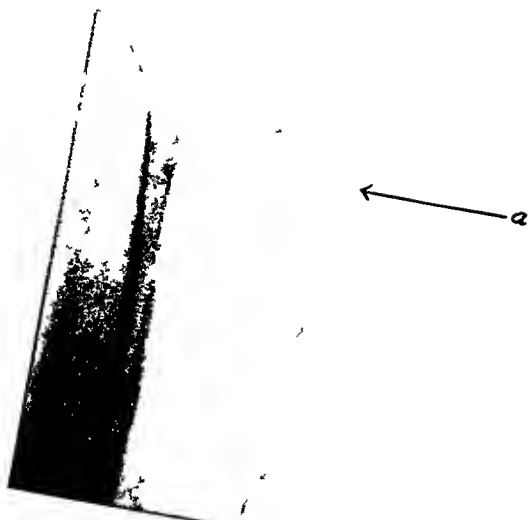


Fig 7

FIG 6—Recurrence of Varicose Veins (a) following Ligation of Great Saphenous Vein. Shunting of blood from femoral (b), to saphenous vein (c), through communicating vein (d) at the upper thigh. Paravalvular bulging because of overload (e)

FIG 7 — Superficial Thrombophlebitis (great saphenous vein not visualized) Femoral vein (a) patent, presents localized duplication (b) Varicosities of lower leg (c)

the saphenous had apparently been obliterated (Fig 5) Reoperation was performed and the communicating vein obliterated by double ligation Subsequent to operation, two injections of sodium morrhuate were made into the remaining varicosities of the lower leg There was prompt obliteration of the varicosities and clearing of the skin manifestations of venous stasis The patient was sent home on therapeutic furlough and was again observed on return, with no evidence of recurrence The soldier has now been restored to full duty

Case 3—A 25-year-old Private, entered military service in August, 1942, and during basic training began to complain of pain in both lower legs In October, 1942, he was operated upon for varicose veins He was returned to duty and felt well for several months In December, 1942, he began to notice a recurrence of the varicose veins and discomfort in the left leg, with evidence of dermatitis in the lower leg Because of inability to do duty, he was finally admitted to McCaw General Hospital for study and disposition On examination, there was evidence of healed bilateral saphenous ligation scars in the groins In the left leg there was a prominent group of varicose veins and the internal saphenous vein was palpably open up to about the midthigh There was evidence of considerable dermatitis and discoloration of the medial aspect of the lower left leg On Trendelenburg and Perthes tests, the deep venous circulation was apparently competent Venographic examination was performed (Fig 6), and indicated that "shunting," by way of a communicating vein in the midthigh, had caused reflux from the femoral vein to the saphenous vein, thereby reestablishing the varicose veins in the lower leg This communicating vein was readily obliterated surgically and the patient made an uneventful recovery After an adequate period of observation, he was finally returned to full duty

Case 4—A 27-year-old Private, had a saphenous ligation performed for varicose veins and recurring varicose ulcer of the lower leg eight months previously On admission to this hospital, there was a fairly large chronic ulcer on the medial aspect of the lower leg Venography was performed and demonstrated that although the great saphenous vein had been well obliterated for most of its course, there apparently remained a markedly dilated tortuous communicating vein coming from the deep veins of the leg and establishing a "venous-lake" at the site of the chronic ulcer This tortuous communicating vein (Fig 4) was readily accessible for surgical ablation

II—THROMBOPHLEBITIS, PHLEBOTHROMBOSIS, AND THROMBO-EMBOLIC ACCIDENTS

A Superficial Thrombophlebitis Superficial thrombophlebitis can be recognized clinically very readily in view of the subcutaneous location of the involved veins or previously existing varicose veins Frequently, however, there is rapid extension of the thrombotic process to the deep venous system with meager or completely absent clinical findings to suggest such an extension Venography of the extremities is, therefore, indicated to demonstrate the possible extension of this thrombosis, with surgical exploration of the femoral vein if there is such an extension The venographic picture of a superficial thrombophlebitis without extension to the deep veins is similar to that of a case in which saphenous ligation has been performed (Fig 7)

B Deep Vein Thrombosis Intravenous clotting associated with inflammatory changes in the walls of the vein usually causes the clinical picture of thrombophlebitis That is, sudden onset of chills, step-ladder rise in pulse and temperature, exquisite tenderness in the calf or along the course of the femoral vein, swelling of the limb, and signs of vasomotor disturbances The

associated inflammatory reaction in the vein wall usually accounts for a rather firmly adherent clot, which, therefore, is less likely to become detached and cause embolization. However, it is recognized that due to stasis, a soft coagulation clot, not firmly attached to the vein wall, can, and fairly frequently does form proximal to the adherent inflammatory clot. This soft, loosely attached clot can be readily detached to form an embolic mass. Intravenous clotting not primarily of inflammatory origin, is a condition known as phlebothrombosis. Such a clot formation is loosely attached to the vein wall and can be easily loosened with resultant embolic accident. The clinical signs of such a phlebothrombosis are entirely absent or only vaguely perceptible, and the early recognition of this extremely dangerous source of pulmonary embolization is impossible on the basis of clinical findings alone. It has been demonstrated on many occasions that venography will definitely establish an early diagnosis of deep vein clot formation. Although thrombophlebitis is commonly suspected as a complication of parturition, pelvic or abdominal surgery, it is not sufficiently realized that deep phlebothrombosis of the extremities may occur or may follow an apparently trivial injury of the lower extremity.

The importance of early recognition of deep vein thrombosis is generally recognized. It has been conclusively shown by workers in many clinics that there is a high incidence of pulmonary infarction resulting from deep phlebothrombosis with a mortality rate of eight to ten per cent in patients beyond the age of fifty. It is, therefore, obvious that the prevention of embolic accidents by femoral vein ligation is extremely important. In the younger age-group encountered in an Army General Hospital, we have performed femoral vein ligation on suspicion, or on roentgenographic demonstration, of a pulmonary infarction. In older individuals we believe it should be an established routine to perform femoral vein ligation on the basis of clear venographic demonstration of deep vein thrombosis. As previously reported by one of us, it has become regular procedure at a large municipal hospital to perform femoral vein ligation in elderly patients prior to amputation for endarteritic or diabetic gangrene. This has resulted in a sharp drop in the incidence of postamputation pulmonary complications and mortality.

Venographic pictures of deep vein thrombosis are of two distinct types, depending upon whether venography is performed during the immediate acute episode or at a later date, when organization and recanalization have occurred. It has been our opportunity to observe both types of roentgenograms. The discussion of venographic findings is concerned with deep vein thrombotic occlusion, whether of thrombophlebitic origin or essential phlebothrombosis. It is our experience with the cases which have been studied to date that we are unable to differentiate on the basis of venograms between thrombophlebitis and phlebothrombosis. The important information offered by the venogram is the detailed graphic demonstration of deep vein block.

(1) *Deep Vein Thrombosis* The venograms of acute, immediate deep vein thrombosis are characterized by the presence of many fine "hairpin-like"

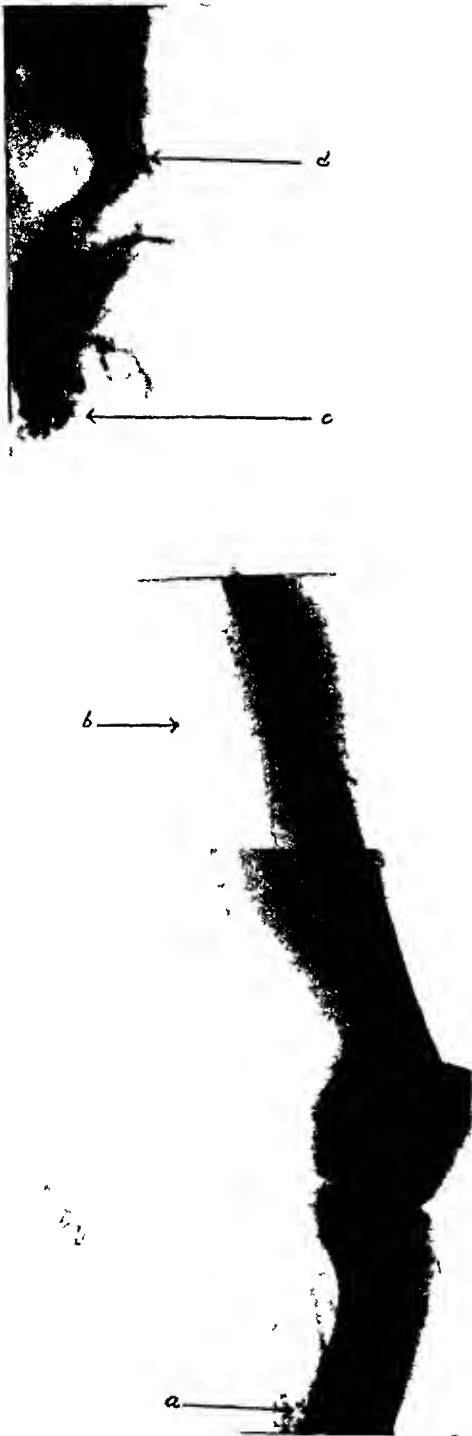


FIG 8—Acute Deep Vein Thrombosis of Femoral and Iliac Veins. Fine, hairpin like venous markings of lower leg (a) and lower thigh. Saphenous vein filled (b) (occluded femoral and iliac veins not visualized). Overflow into superficial pudendal (c) and superficial epigastric (d) tributaries.

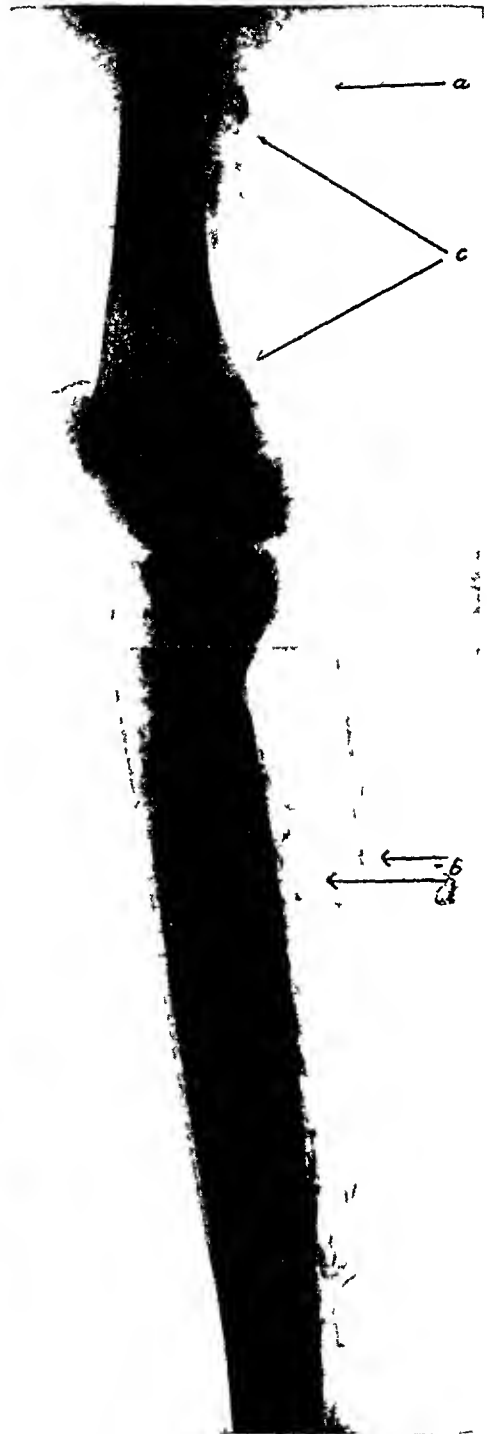


FIG 9—Acute Deep Femoral Vein Thrombosis. Saphenous vein visualized (a). A network of "hairpin like" venous markings along the upper and lower leg (b), and segmental filling defects of femoral vein (c), both characteristic of acute occlusion.

venous markings in the leg and lower thigh (Figs 8, 9 and 15d) These markings are probably a group of previously unused small venous collaterals The appearance of the major deep veins from the venae comites in the leg to the femoral vein in the groin, may show sudden blunting obstruction and sharp segmental defects in the lumen (Fig 15d) It is our impression that the venographic findings of numerous fine "hairpin-like" venous markings and sharp segmental defects are pathognomonic of acute deep vein occlusion, and that these findings have not been previously described in the literature

Case 5—A 23-year-old Private, was injured while on foreign combat duty, when he was struck in the right hip and thigh region with a large heavy case of ammunition A diagnosis of a fracture of the neck of the femur was made and a large spica plaster encasement applied, the patient was then transported by airplane back to the States On arrival at this hospital, roentgenograms of the hip were repeated and found to be negative for fracture On the day following admission, the patient had a rise in temperature, and complained of pain in the right lower extremity The encasement was removed and, on examination, there was suggestive tenderness in the calf region and slight edema about the lower leg and ankle Venography was performed (Fig 8) and demonstrated the typical findings of an acute deep vein thrombosis of the femoral vein This patient was treated conservatively in view of the absence of any pulmonary complications, and made a satisfactory response to repeated paravertebral blocks with novocaine This patient, after a sufficient period of observation, and convalescent furlough, has been restored to full duty

Case 6—A 21-year-old Private, was operated upon for a tuberculous empyema About 24 hours after operation, the patient complained of pain in the calf of the left leg and, on examination, slight pitting edema about the ankle region and exquisite tenderness of the calf muscles was noted Venography was performed (Fig 9) and demonstrated all the typical findings of an acute deep vein thrombosis In view of the extensive chest pathology already existing and the obvious difficulty in determining the occurrence of any additional pulmonary accident, it was decided to explore the femoral vein in the groin A large fresh thrombus was evacuated from the femoral vein and the vessel was then doubly ligated and cut between ligatures Following operation, the circulatory status of the limb returned to normal and remained so until the patient's death from military tuberculosis three months later

(2) *Chronic Deep Vein Thrombosis* We have observed and studied at McCaw General Hospital a rather large group of cases with the history and clinical findings of an old or chronic state of deep vein occlusion These patients complained of mild to moderate swelling of the affected extremity with a feeling of weight and discomfort in the leg aggravated by prolonged standing or marching In some cases where recanalization has been fairly ample, symptoms and findings in the lower extremity may be very mild The venographic picture in the case of chronic or old deep vein thrombosis is characterized by a partial or total absence of visualization of the femoral vein, the popliteal vein or the venae comites of the leg Marked irregular narrowing defects or the so-called "patchy or moth-eaten appearance" of the vein may be noted (Fig 15e) The latter has been described as "mantle filling" by other authors In some instances, tortuous collateral vessels may be seen to "bridge over" a defect in the main vessel (Fig 10) The superficial venous return is usually quite prominent and may be responsible

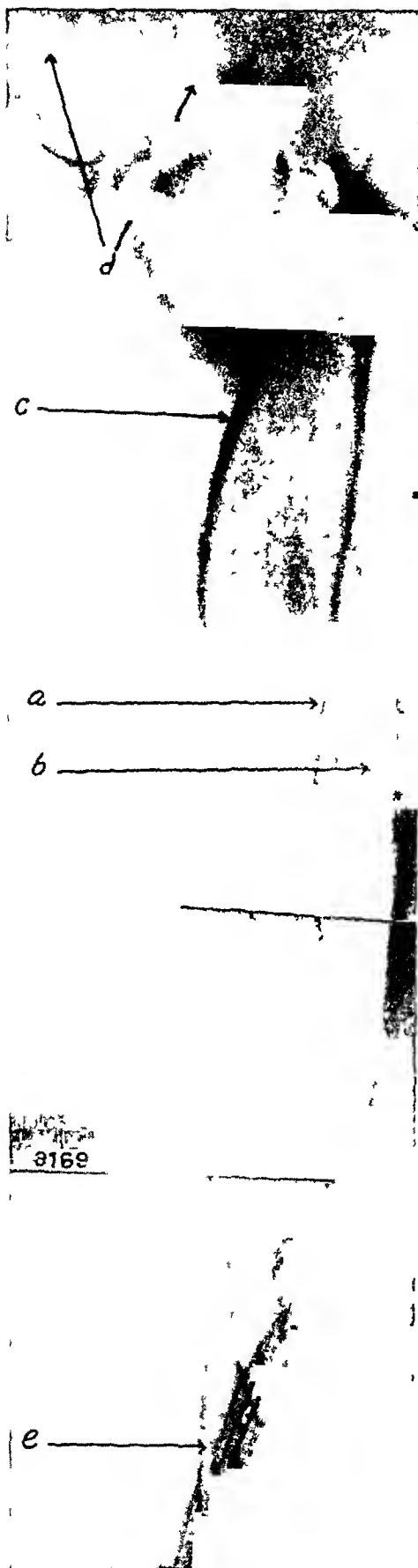


FIG 10—Old femoral vein thrombosis following appendicectomy, with recanalization (a) and bridging (b) of the involved portion. Note prominence of great saphenous vein (c) and overflow into external superficial pudendal vein (d). Varicosities of both internal and external saphenous vein in the lower leg (e).

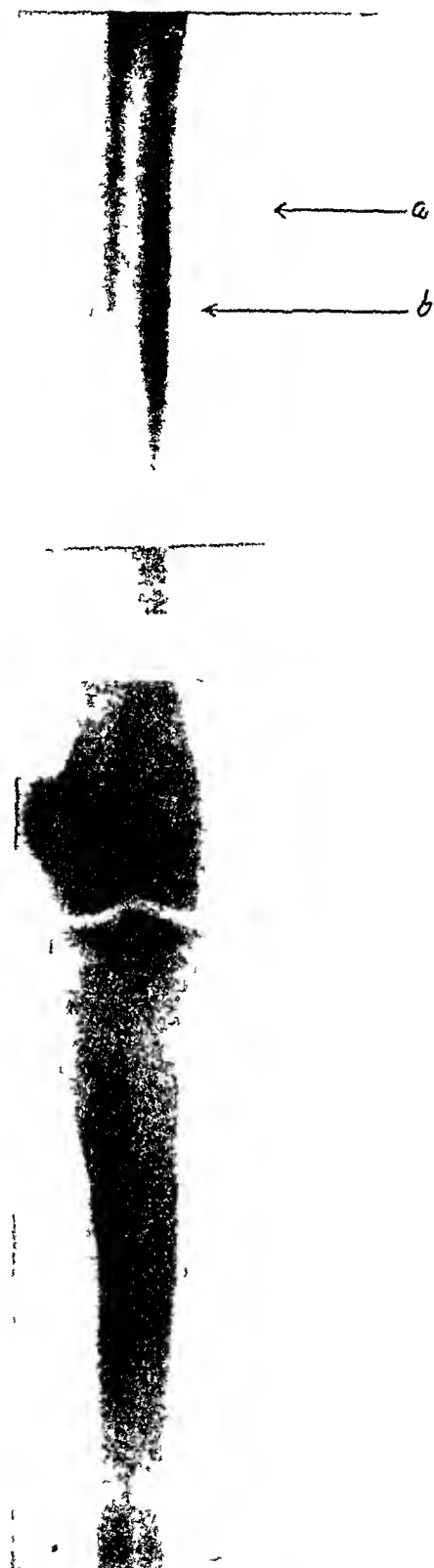


FIG 11—Old femoral vein thrombosis following appendicectomy and gas bacillus infection aggravated by saphenous ligation and sclerosing therapy of varicosities seven years after appendicectomy. Present clinical picture of severe lymphedema of the leg. Patchy moth-eaten femoral vein (a). Great saphenous vein not visible (recent ligation). Bridging of femoral defect (b).

for the formation of varicose veins. In many cases of deep vein occlusion the superficial venous tributaries in the groin and lower pelvis (the superficial external pudendal, the superficial iliac circumflex and the superficial epigastric) are visualized as extremely tortuous and prominent. These tributaries have never been visualized in the venograms of the normal extremity, and are considered to be characteristic of old deep femoral vein occlusion. These tortuous veins in the groin may become so prominent as to cause an erroneous diagnosis of femoral hernia, as will be described in one of the case reports. Again, we wish to emphasize that the venographic findings of numerous fine, wavy, hairpin-like venous markings are not encountered in the old or chronic cases in which recanalization and compensatory venous return of the extremity has been established, but only in the cases of acute or immediate deep vein thrombosis.

It is interesting that in about 50 per cent of the cases of old or chronic femoral vein occlusion observed at this hospital the acute episode had occurred about ten days following appendectomy.

Case 7—A 32-year-old Private, was operated upon for acute appendicitis nine months previously. On the ninth day of an apparently uneventful postoperative course, he developed the rather typical findings of an acute deep vein thrombosis. Because of obesity and persistent symptoms of swelling and discomfort in the leg on walking, the soldier was admitted to this hospital for study and disposition. Venography (Fig 10) demonstrated definite evidence of an old, deep vein thrombosis, partially recanalized, with compensatory varicose veins. This patient was recommended for separation from the service.

Case 8—An obese 38-year-old Private, was operated upon for acute appendicitis in 1934. He developed a gas gangrene infection of the abdominal wall, requiring multiple extensive incisions of the lower abdomen and thigh region. Shortly thereafter he was aware of considerable discomfort and tenderness in the right calf followed by a moderate degree of swelling of the right lower extremity. Subsequently, he began to notice the presence of prominent varicose veins in the right lower extremity, with little or no symptoms referable to the presence of these veins. In November 1942, shortly after induction into military service this soldier was treated with saphenous ligation and several injections of sclerosing solution into the varicose veins. Shortly thereafter, he developed a severe, painful swelling of the entire right lower extremity with marked acute inflammatory signs. This condition subsided after several weeks of bed rest and wet dressings. He was admitted to this hospital, in August, 1943, for study and disposition, venography (Fig 11) was performed and demonstrated the existence of an old, deep vein thrombosis. It is our impression that this condition had occurred during or shortly after the series of surgical procedures in 1934, and that the superficial varicosities were a part of the compensatory mechanism for venous return. The performance of saphenous ligation, followed by the use of sclerosing injections, without information concerning deep vein pathology, apparently brought on a severe inflammatory reactivation of the old thrombotic process, with further embarrassment of the return venous circulation. This soldier was eventually recommended for separation from the service.

In other cases the acute deep vein occlusion has apparently occurred insidiously or following relatively mild trauma to the extremity. In this latter group the presence of a deep phlebothrombosis had been overlooked in some instances.

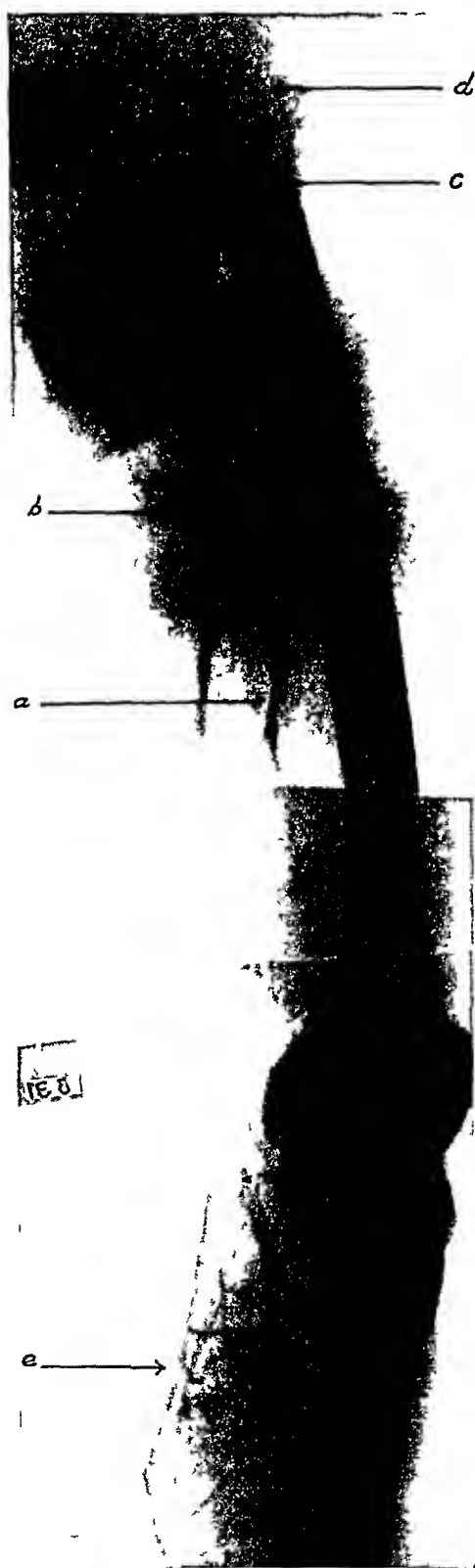


FIG 12—Old femoral vein thrombosis following severe ankle sprain. Subsequent development of tortuous venous tributaries in the groin, led to erroneous diagnosis and surgical exploration for femoral hernia. Patchy moth eaten appearance of femoral vein (a). Prominent great saphenous vein (b). Overflow into superficial external pudendal vein (c) and circumflex iliac vein (d). Compensatory varicosities of lower leg (e).

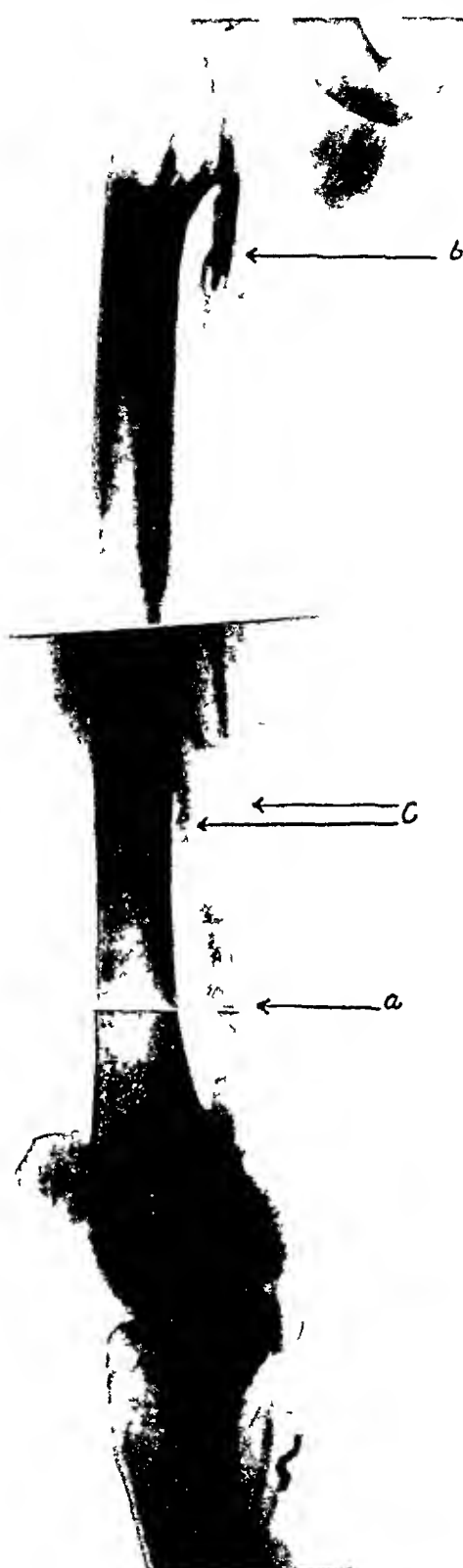


FIG 13—Rare Observation of Tortuous Dilatation of Lower Femoral Vein (a) Old deep vein thrombosis (b) Bridging of femoral vein (c) Great saphenous vein not visualized (surgical ligation). Chronic leg ulcer following saphenous ligation in the presence of undiagnosed deep vein pathology.

Case 9—A 40-year-old 1st Lieutenant, suffered a sprain of the ankle and lower leg in February, 1943, while on foreign duty. This was treated with several days of bed rest, elevation and application of wet dressings. About one week later there was a recurrence of pain in the lower leg, with pain, swelling and tenderness in the thigh and groin. This discomfort and swelling of the lower extremity subsided to a moderate degree. Four months later, because of a persistent bulge in the groin, the patient was operated upon for femoral hernia. The operative report states that no hernia was found but that a group of enlarged tortuous veins was encountered in the region of the fossa ovalis. The officer was referred to this hospital for study and disposition. The physical findings in the lower extremity were those of mild pitting edema and presence of a moderate number of superficial varicose veins in the leg. Venographic examination (Fig. 12) demonstrated an old venous thrombosis with recanalization and marked tortuous dilatation of the superficial pudendal, epigastric and circumflex iliac veins in the groin and lower pelvis. History and findings indicated that the presence of a deep vein thrombosis following ankle sprain had been overlooked, and the prominent venous bulge of tributaries in the groin had been erroneously diagnosed as a femoral hernia.

In some cases the original clinical history was that of pneumonia, with three to four recurrences of acute pulmonary episodes characterized by severe chest pain, bloody sputum, chills, spiking temperature and roentgenologic evidence of pulmonary pathology. Obviously, these were manifestations of recurring pulmonary embolic accidents originating in a deep thrombosis of the lower extremity. Were such accidents to occur in an older age-group of patients, a definite mortality rate would be encountered. Venography in such suspicious or suggestive pulmonary conditions would reveal the source of emboli, with proper performance of femoral vein ligation.

Case 10—A 26-year-old Corporal, suffered an acute chest condition in December, 1942, which was diagnosed as pneumonia. At about the same time he noticed pain and swelling of the left leg, which he believed had followed a trivial injury to his leg shortly before entering the hospital. He was making a satisfactory recovery until two weeks later, when he again developed pain in the chest, a sharp rise in temperature and blood-streaked expectoration. Patient was hospitalized for an additional month and then discharged to duty. Because of continued swelling and discomfort in the left lower extremity, he was referred to McCaw General Hospital for further study. On examination, there was slight pitting edema of the lower two thirds of the leg and some evidence of vasomotor disturbance. Venography revealed definite evidence of an old, deep vein thrombosis involving the popliteal and femoral veins. It is our impression that the presence of an acute deep vein thrombosis was the source for the original embolic pulmonary infarct diagnosed as pneumonia.

Case 11—Another extremely interesting case of combined pulmonary and deep vein pathology was observed. A 28-year-old soldier, was admitted for study three months after his first attack of "pneumonia." He subsequently had three additional episodes of so-called relapsing pneumonia at intervals of two to three weeks. Roentgenologic studies of the chest suggested the possibility of recurring infarctions, and venography demonstrated the presence of an old, deep vein thrombosis. Because of these recurring episodes, it was felt that complete organization of the thrombotic process had not occurred, even at this late date, and that embolic masses were breaking off periodically. Femoral vein exploration and ligation was performed, with demonstration of an old thrombotic process. This patient was subsequently sent on furlough, and then returned to the hospital for an adequate period of continued observation. The patient remained entirely well, and has since been returned to full duty.

Case 12—A 38-year-old Private, was referred to McCaw General Hospital because of recurring ulceration of the medial aspect of the left lower leg. About 15 months ago, shortly after entering military service, he had a saphenous ligation, with retrograde sclerosing injection, for varicose veins of the lower leg. The patient stated that prior to ligation, he had had considerable discomfort and aching in the left leg induced particularly by drilling and marching, however, he had had no inflammation or ulceration of the skin. Shortly after ligation, this soldier developed a rather large ulceration on the medial aspect of the left lower leg. When treated with absolute bed rest and elevation of the leg, the ulcer healed. However on each occasion when the soldier was sent back to duty, the ulcer promptly recurred, requiring almost continuous hospitalization. Venography was performed (Fig 13) at this hospital and revealed evidence of an old thrombosis of the upper femoral vein with marked tortuosity and dilatation of the lower femoral vein (this type of tortuosity of femoral vein has never been visualized before in any of our venographic studies). It is our impression that this soldier had had a previously unrecognized deep vein pathology, with secondary superficial varicose veins and that, here again saphenous ligation for varicose veins in the presence of impaired deep vein circulation had aggravated the pathology and resulted in a chronic leg ulcer. This soldier was considered unfit for active duty and recommended for separation from the service.



FIG. 14—Visualization of Iliac Vein (7)

A survey of these cases of old or chronic deep vein thrombosis reveals that the residual sequelae of mild to moderate lymphedema of the extremity with associated discomfort on prolonged standing or walking and some vasomotor symptoms are more or less permanent. Although various measures can be utilized to control or minimize the discomfort of these symptoms the fact remains that once lymphedema of an extremity has been in existence for a period of months, there is no curative therapy available except for radical surgery in a very low percentage of cases which go on to elephantiasis proportions. Therefore the majority of the cases which we have seen late in the existence of pathology re-

quired separation from the service because of swelling and discomfort in the extremities. On the other hand, were these cases to be recognized immediately after the occurrence of the acute deep vein thrombosis we believe that the utilization of repeated paravertebral block, in the inflammatory thrombophlebitis cases, and heparin or dicoumerin therapy, would prevent delayed residual symptoms due to swelling of the limb, and that prompt femoral vein ligation, when indicated would prevent the danger of an immediate embolic accident. It is not our particular purpose in this communication to elaborate on the etiology or therapy of deep phlebothrombosis and thrombophlebitis, but essentially to stress the fact that immediate diagnosis

VENOGRAPHY

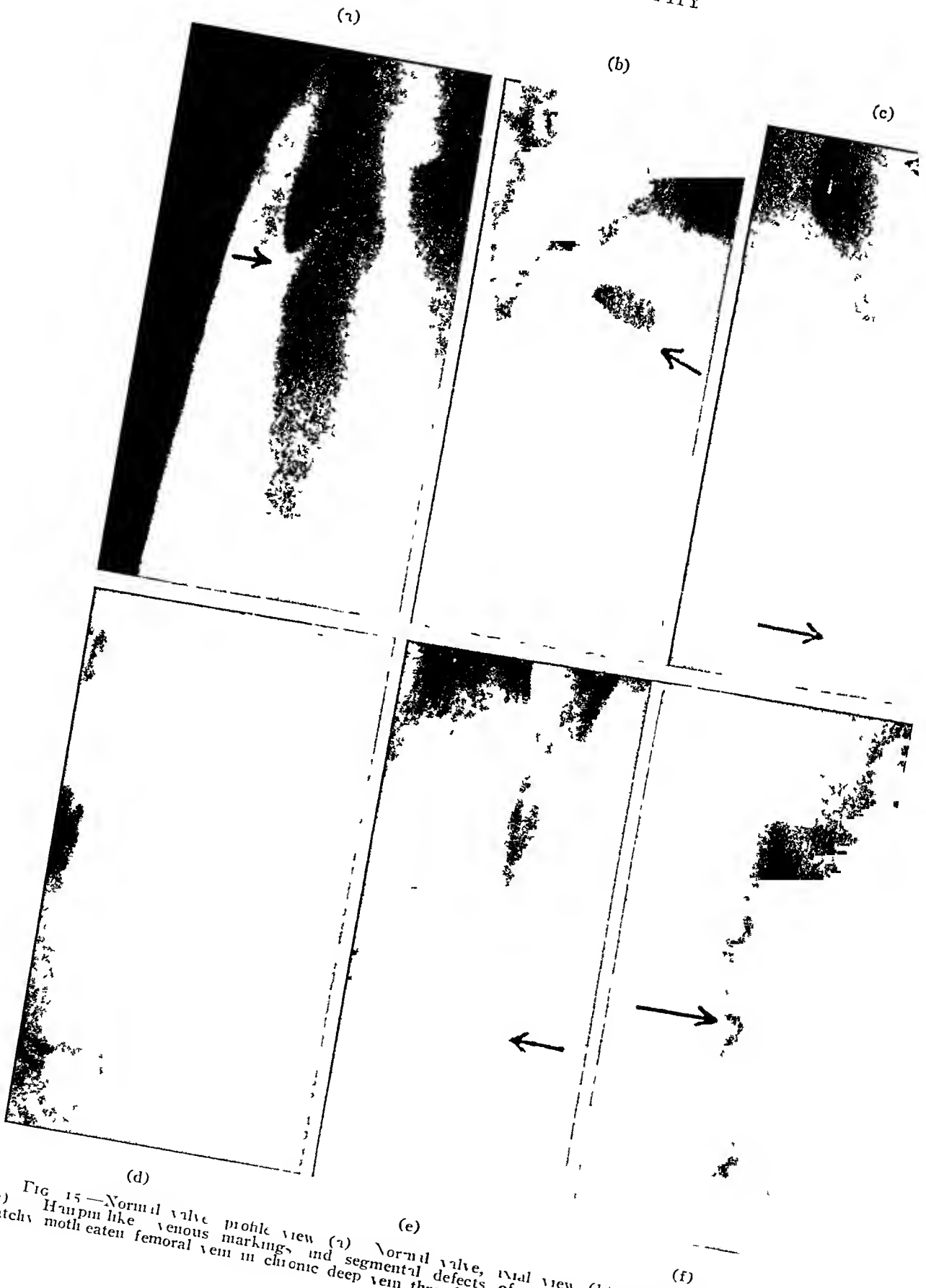


FIG. 15—Normal valve profile view (a) Normal valve, axial view (b) Paravalvular bulging (c) Hump-like venous markings and segmental defects of acute deep vein thrombosis (d) Patchy moth-eaten femoral vein in chronic deep vein thrombosis (e) Cauliflower varicosity (f)

of an acute thrombotic process of the deep veins is important, and can be best demonstrated by the use of venography

SUMMARY

1 The roentgenologic technic and various diagnostic criteria of pathology in the venous circulation of the lower extremities have been described and illustrated

2 The clinical case-groups of venous disturbances of the lower extremities encountered at an Army General Hospital have been described in relationship to their study by venography

3 The importance of venography in the study of (a) recurrent varicose veins and their complications, and (b) thrombosis of the veins of the lower extremities, is illustrated in a group of case reports

4 Particular stress is placed upon the immediate diagnosis by venography of the acute thrombo-embolic processes in the lower extremities with respect to prompt femoral vein ligation in the prevention of pulmonary embolic accidents

5 It is our belief that many of the late disabling sequelae of deep vein thrombosis of the lower extremities could be prevented by prompt recognition with venography and the prompt use of the recognized therapeutic measures

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PECTUS EXCAVATUM

REPORT OF TWO CASES SUCCESSFULLY OPERATED UPON

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UNTIL Dr. A. Lincoln Brown¹ reported his operation experiences with the correction of the deformity known as pectus excavatum were disappointing. The application of traction by various methods and the several plastic procedures, mostly of a minor and inadequate nature were of necessity doomed to failure when considered in the light of an accurate understanding of the anatomic facts regarding the deformity. There were obvious objections to resection of a part of the sternum although that radical procedure was of course better calculated than any others then available to relieve extreme degrees of pressure upon and displacement of the heart.

At the Massachusetts General Hospital our attempts to correct or relieve the condition in a few cases resulted in complete or partial failure and the thought of operating upon such patients had been practically abandoned.

In 1943, the opportunity arose to apply the principles put forth by Doctor Brown. The success of the operation in these two cases prompts me to report them in considerable detail. It is desirable also to propose certain minor modifications of technic which may be worth the consideration of those who have occasion to perform this ingenious operation.

In May 1943, Dr. Paul White referred to the Surgical Service two sisters, age 14 and 5 years respectively, for consideration of the possibility of surgical correction of pectus excavatum. The elder child had suffered serious circulatory disturbances as a result of this deformity which in her case was of extreme degree. But in addition she was much disturbed emotionally because of the anomaly. Her embarrassment because of the deformity was so extreme that she refused to wear a bathing suit and was exceedingly shy about allowing anyone but her physicians to see her chest without clothing. She had grown rapidly and was taller than other girls of her age. She was so sensitive about her unusual height that she had accentuated her naturally stoop-shouldered posture so as to diminish her apparent tallness. The resulting poor posture tended to accentuate the chest wall deformity. Thus, she presented two cardinal indications for surgical correction of the pectus excavatum, namely disturbances of the circulatory mechanism and the unfavorable effect of the deformity upon the psychology of the patient. In the hope that her appearance might be improved, this child was eager to be operated upon.

In the case of the younger sister no symptoms had been observed and she was too young to be disturbed about her appearance. But the deformity had become steadily more prominent as she had grown from infancy.

There was no clear-cut history of other examples of the deformity in the family. There were four siblings, all of whom were normal. The father, who was normal, had died. The mother was of the impression that one paternal uncle had a pectus excavatum but her knowledge of her husband's family was incomplete. The mother's family was free from any suggestion of the deformity for at least several generations.

ANATOMIC CHARACTERISTICS OF THE DEFORMITY

Without attempting to elaborate upon the possible causes of pectus excavatum or to improve upon the excellent description of the abnormal anatomy given by Brown,¹ several impressions resulting from the study of the two sisters referred to in this communication are presented. In each case the diaphragmatic attachments to the sternum, the importance of which is stressed by Brown, were found and cut as a part of the operative technic, but these structures were not abnormally large or strong. The substernal membrane or ligament did not appear to be a very important structure in these cases. The degree of depression of the gladiolus, however, was so severe in the older girl that the apex of the funnel-shaped deformity was actually about 1 cm posterior to the plane of the anterior surface of the vertebral bodies and to the left of them. In the younger girl there was just room enough during expiration to insert a finger between the deepest portion of the sternum and the anterior surface of the vertebral bodies.

The skeletal deformity in both cases was characterized by what appears to be an anomaly of both the sternum and the costal cartilages, and of necessity the costochondro-sternal articulations of the lower three or four ribs. One is impressed in pectus excavatum by the fact that the gladiolus of the sternum after being freed from its attachments within the mediastinum and liberated from the costal cartilages so as to bring it up from the bottom of the deep depression, is of essentially normal size and shape. Its upper portion near the manubrio-gladiolar junction has a posterior inclination, but once this has been corrected by a wedge-shaped transverse osteotomy the gladiolus appears to be normal. Its inferior end, actually at its junction with the xiphoid, represents the deepest point of the funnel deformity, the sides of which are made up of costal cartilages, upper abdominal wall, xiphoid, and gladiolus itself. When the deformity is well marked, no amount of release of pull by dividing the substernal attachments of the diaphragm, the ligaments, or the fasciae would appear to have much effect on improving the condition. In the cases with a deep depression it seems almost as though the sternum is pushed down against the spine by unusually long, inward-curving costal cartilages rather than that it is pulled down to the spine by the attachments beneath. Experience with the operation proposed originally by Brown, and described here, demonstrates that unless appreciable lengths of the lower costal cartilages are resected it is impossible to correct the deformity even after releasing the pull of the substernal diaphragmatic and fascial attachments and the removal of a wedge of bone at the upper limits

of the gladiolus. One gets the impression therefore, that the deformity may be primarily skeletal.

That there is, however, an inward motion of the lower end of the sternum during inspiration was well demonstrated in each of the two girls whose cases are under discussion. This was obvious from the measured decrease in the anteroposterior diameter of the chest on deep inspiration as compared with full expiration. It was also observed at operation most strikingly in

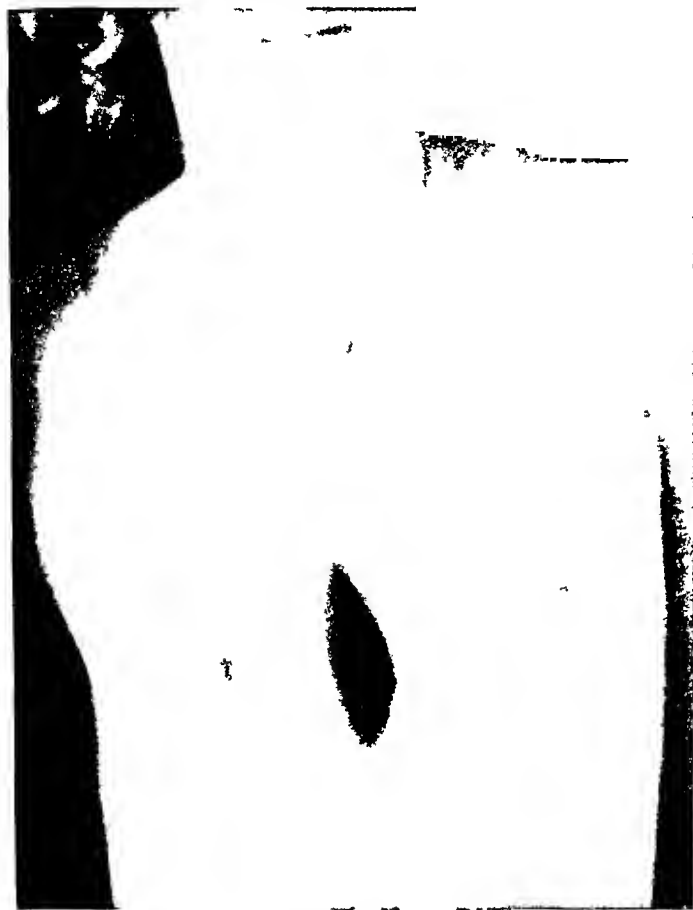


FIG 1.—Case 1. Preoperative appearance of the chest, showing marked pectus excavatum. Note the locket hanging off the chest wall because of the funnel shaped depression.

the younger child. In her case at operation during expiration there was just room enough to insert the index finger between the posterior surface of the sternum and the anterior surface of the spine. But during inspiration the sternum was depressed so firmly that the finger could not be withdrawn until released by the relaxation which occurred during expiration. This occurred even after the diaphragmatic attachments to the sternum itself had been severed.

CASE REPORTS

Case 1—M. G. H. No. 343479. J. H., female, age 14, was admitted to the Massachusetts General Hospital, September 7, 1943, because of a marked funnel chest deformity,

which had been present since birth and which had become worse as the patient had grown older. About four years before admission she had begun to have attacks of palpitation coming on at irregular intervals and lasting from four to 24 hours. During these attacks the pulse had been regular, but the rate had gone up as high as 150 according to the patient's mother. She had had no dyspnea, chest pain, or pain in the arms associated with these attacks, but her mother said her lips had been blue during them. Following the attacks she had occasionally had slight pain in her chest lasting for an hour or two. There had never been any evidence of rheumatic fever or joint trouble.



FIG 2—Case 1. Plaster model made directly from the patient by Dr. Carroll Larsen for the purpose of studying the deformity and as a permanent record for future comparison. This shows the extreme depth of the sternal depression somewhat more clearly than the photograph of the patient.

She had been studied in the Cardiac Clinic where a diagnosis of paroxysmal tachycardia had been made. On roentgenologic examination it was found that the lower extremity of the sternum touched the vertebral bodies. In the anteroposterior view the heart shadow was entirely in the left hemithorax extending to the left chest wall. The transverse diameter of the heart was 14.5 cm. The internal diameter of the thorax was 23.5 cm. In the right anterior oblique view the transverse diameter of the heart became 11.2 cm and in the lateral view the depth of the heart measured about 8.4 cm. The heart appeared to be enlarged as well as flattened. An electrocardiogram showed rather marked right axis deviation with slight elevation of ST₁ and slight depression of ST₃, which was interpreted as evidence of quite marked right

ventricular strain and hypertrophy. These changes were believed to be dependent upon compression of the heart by the sternal deformity rather than on an associated cardiac defect, congenital or valvular. A consultation was, therefore, requested as to the possibility of surgical correction of the deformity.

There was no definite family history of funnel chest, but the patient's sister five years old, had the same condition. Her father was known to have heart disease for a few months prior to his death from coronary thrombosis a year before her admission to the hospital and a paternal uncle and grandfather had some heart disease.

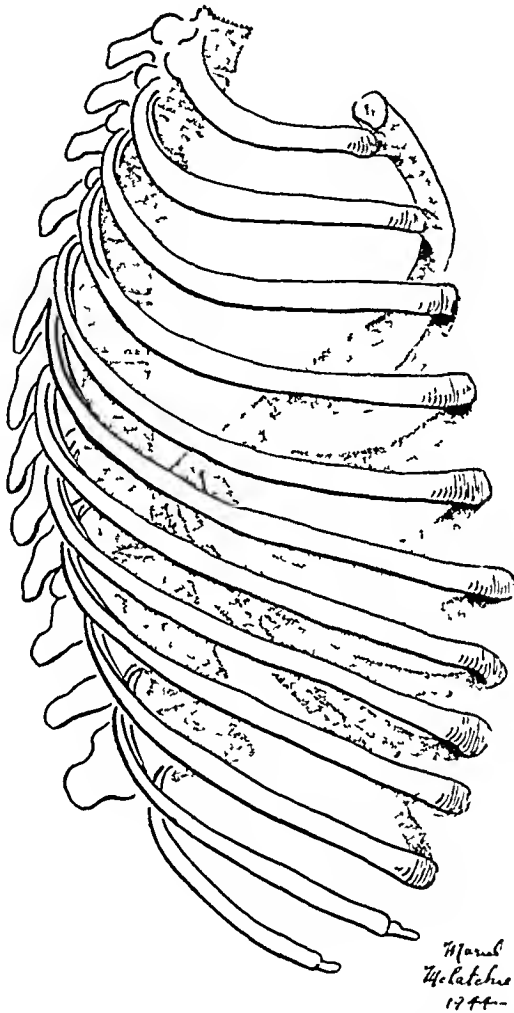


FIG. 3.—Case 1. Diagram of rib cage. Lateral view showing the relation of the sternal depression to the dorsal spine. Note the elongation and deep incurving of the lower costal cartilages.

Physical Examination—This showed a tall, thin girl, age 14, with a long thin chest. There was some left middorsal scoliosis with a reverse dorsal curvature of the spine above this, but no kyphosis. There was marked depression of the sternum with a distance of only 9 cm. between the front of the sternum at the depth of the deformity and the back of the spine. The trachea was deviated to the left and the entire heart appeared to be pushed into the left chest. The pulse was regular at 80. Blood pressure 130/80. There was no edema and no evidence of arthritis. The lungs were clear and resonant. On examination of the heart the apex impulse was felt in the seventh interspace in the midaxillary line, 12 cm. from the midsternal line and 4 cm. beyond the midclavicular line. There was no dullness above the third rib, but the left border of cardiac dullness

PECTUS EXCAVATUM

agreed with the palpable impulse. The right border extended to the sternum. P2 was double. There was a moderate harsh systolic murmur at the apex, slight at the base. No diastolic murmurs were heard. The apical systolic murmur was loud at the left lung base in the back. Chest expansion at the upper thoracic level was 1 inch, at the lower thoracic level 1.5 inches, measured with the spine straight. Laboratory examination of the urine was negative. The red blood cell count was 5,700,000 and the hemoglobin 90 per cent. Hinton test was negative.

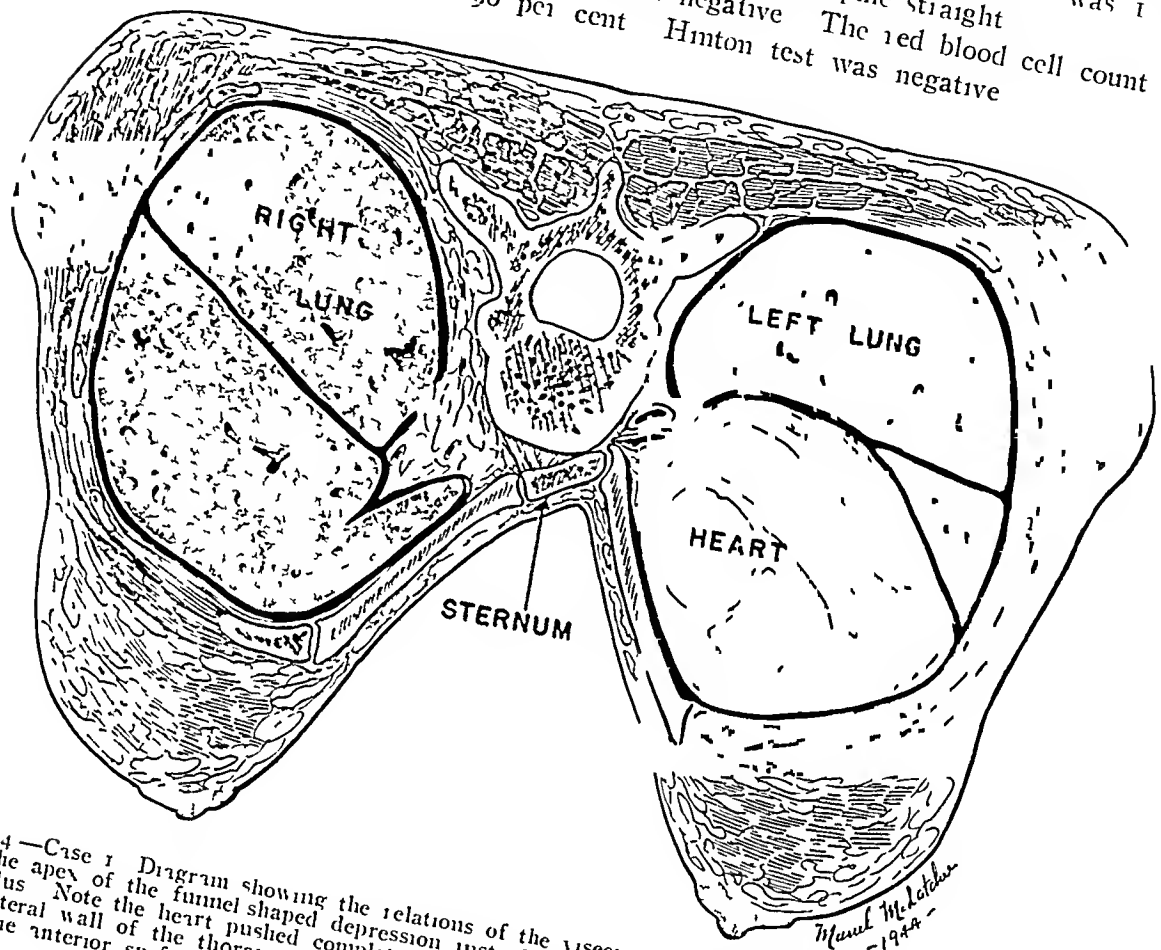


FIG 4—Case 1. Diagram showing the relations of the viscera and the chest wall deformity at the level of the apex of the funnel shaped depression just above the junction of the xiphoid process with the gladiolus. Note the heart pushed completely into the left side of the chest with its apex against the left lateral wall of the thorax. The deepest point of the depression is actually posterior to the plane of the anterior surface of the vertebral bodies.

Operation was planned for October 1, but after the patient had reached the operating room, she had a sudden attack of paroxysmal tachycardia, with cyanosis and slight congestion of the neck veins. The pulse rate was over 160, and the blood pressure fell to 80 mg of Hg systolic. There was prompt relief after the intravenous injection of 6 cc of cedilamid and on October 3, the patient was started on two grains of quindine tid. Her course was satisfactory and operation was finally performed on October 9, 1943.

Operation—A vertical midline incision was made. The xiphoid process was removed, the rectus abdominus muscles were reflected from their attachments to the sternum and adjacent costal cartilages, and the diaphragmatic attachments were cut. The costal cartilages were then divided, but it was observed before this was done that the sternum was pulled in so deeply that it lay to the left and posterior to the anterior surface of the vertebral column. After cutting the costal cartilages all the way up to the second, it being necessary to divide the third in this patient, a transverse wedge-shaped piece of bone was removed from the sternum just below the articulations of the second cartilages. Three wire sutures were used to hold the trimmed lower portion of the sternum up in the proper position. Large segments of costal cartilage were

removed, fitting each one in turn so as to restore the chest to a reasonably normal contour. These were held in place by heavy silk sutures. Following this the muscle layers were reattached excepting the diaphragm. In closing the skin it was necessary to remove a redundant portion from one side because of the fact that after the deep funnel-shaped deformity had been corrected, there was too much skin.

The patient's postoperative course was complicated only by two attacks of paroxysmal tachycardia occurring one day and 12 days after operation, with improvement on administration of quinidine. An electrocardiogram taken on the 12th day showed the P waves more prominent than formerly. She was instructed in good posture and arm positions to assist in chest elevation and was discharged in good condition on the 17th postoperative day.

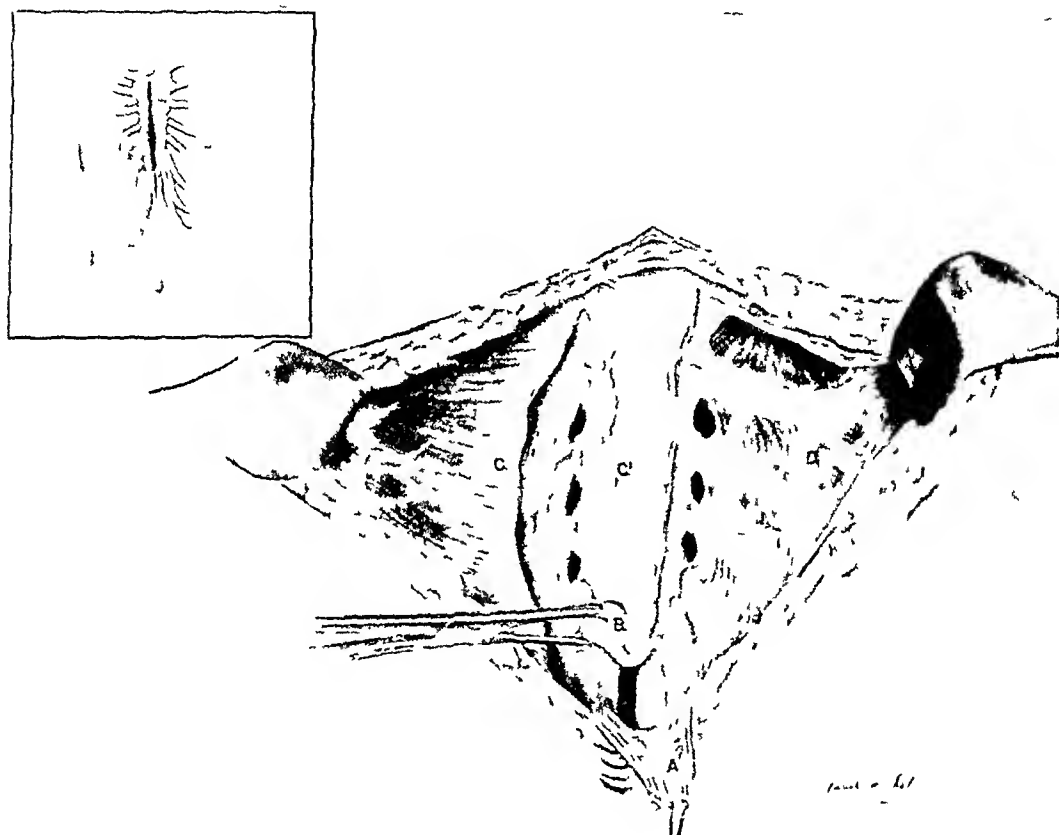


FIG 5—Case 1. Beginning of operation showing exposure. Insert gives line of incision. (A) Lower costal margin and a portion of each rectus abdominis muscle reflected after freeing from xiphoid and lower costal margin, (B) xiphoid process held up with tenaculum, (C) fascia of the pectoralis major muscle after separating it from the anterior surface of the sternum (C'), (D) pectoralis major muscle freed from underlying costal cartilages and retracted.

The patient reported for a postoperative check-up a month after discharge from the hospital. She had been fairly well except for a few short spells of paroxysmal tachycardia. The wound was well healed. The sternal depression was largely corrected so that the distance from the front of the sternum to the back of the spine was about 13 cm. The apex impulse was felt in the fifth interspace, 9 cm to the left of the midsternal line. The systolic murmur was present in the left back as before. Fluoroscopy showed a large heart shadow, rather flattened anteroposteriorly and largely in the left thorax, but there was much more room in the mediastinal space. An electrocardiogram showed little change. T₂ was less inverted, which was interpreted as possibly a sign of decreased right ventricular strain.

PECTUS EXCAVATUM



Fig 6—Case 1 Diagram to illustrate freedom of the sternum from the costal cartilages. The third cartilages have not yet been cut across. Note how the cartilages fall together after pulling sternum up. Line A indicates the location of the cartilage divisions across the cartilages. All the costal cartilages between this line and the margin of the sternum is to be disordered.

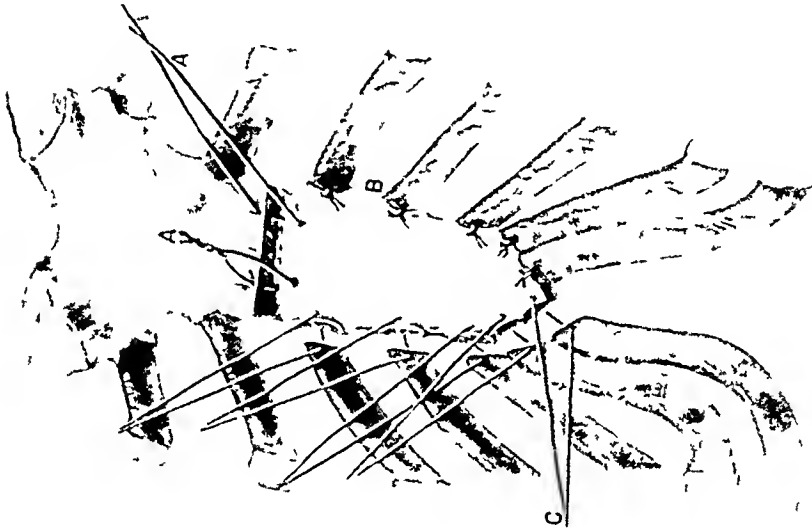


Fig 7—Case 1 Diagram to illustrate the method of fixing the sternum in its elevated position by wire sutures, (A) which approximate the edges of the defect left after removing a transverse wedge of the bone below the level of the second costal cartilages. Heavy silk sutures used to fasten the costal cartilages to the sternal edge shown tied on the left (B) and ready to be tied on the right (C).

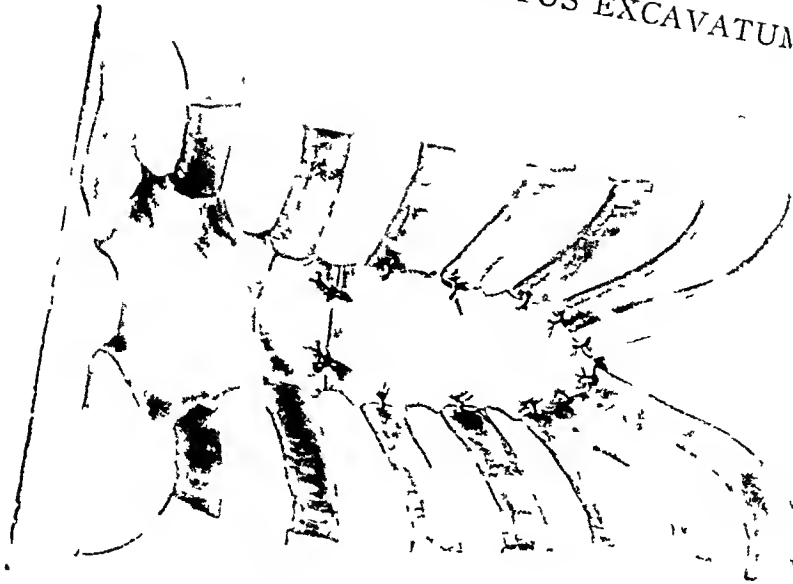


Fig 8—Case 1 Diagram showing all sutures in place after trimming the cartilages and removing a transverse wedge from the sternum, thus correcting the funnel shaped depression.

Case 2—M G H No 384900 P H female, age 5, sister of the patient described in Case 1 was admitted to the Massachusetts General Hospital, September 9, 1943, because of an apparently congenital funnel chest deformity. When the patient was six months old the mother had first noticed a depression of the anterior chest which had become more prominent as the patient became older. She had had no complaints and her activity had not been limited. There was no history of bone pain, fractures, swelling, or pain in the joints. She had been seen in the Cardiac Clinic ten months prior to admission where a diagnosis of tunnel chest, with displacement of the heart

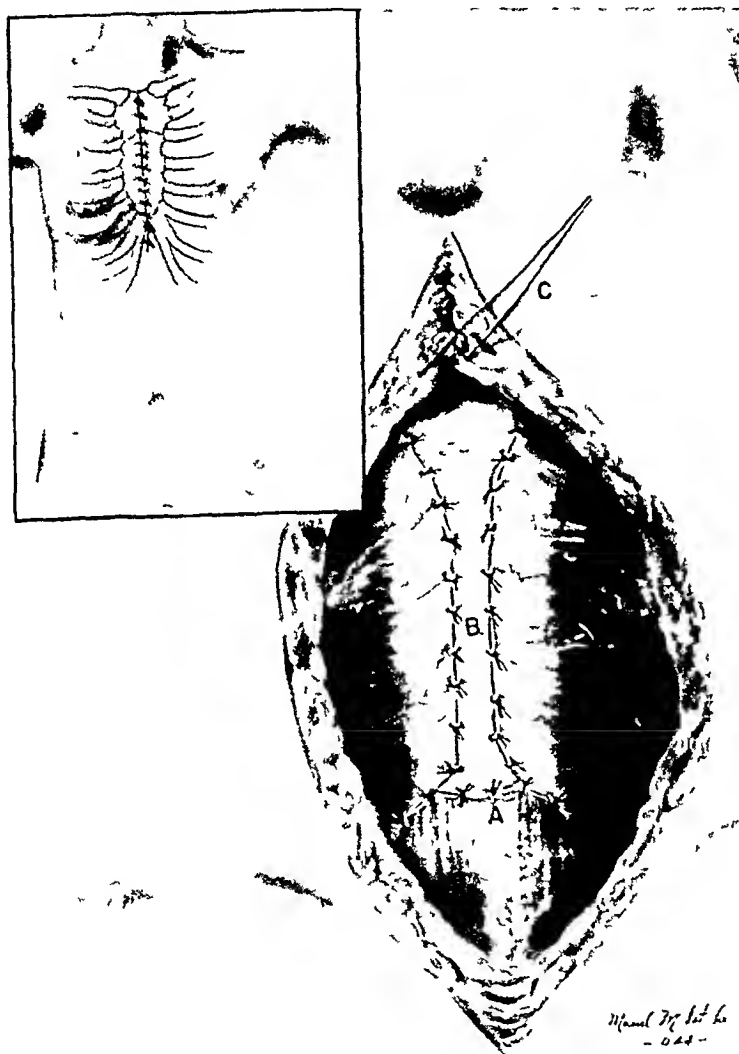


FIG 9—Case 1. Completion of the operation. Diagram showing suture of rectus muscles and linea alba to the lower costal cartilages and sternum (A), suture of pectoralis major muscle fascia to the sternum on each side (B), closure of the superficial fascia and fat begun (C). Insert shows completion of skin closure.

to the left and questionable cardiac compression had been made. Examination of the heart at that time by fluoroscope showed it to be almost entirely in the left chest and not much enlarged. An electrocardiogram was reported to be within normal limits.

Physical Examination—This showed a well-developed and well-nourished girl, with good color. There was a large, hemispherical depression in the mid and lower sternum, about 3 x 3 cm, with characteristic sinking-in on deep inspiration. There was a moderate degree of scoliosis, apparently structural, with convexity to the left in the thorax and to the right in the lumbar region. Examination of the heart showed

PECTUS EXCAVATUM

the apex in the midaxillary line, impulse forceful, sounds of good quality. Rate was 100 and rhythm regular, with a rare extrasystole. There was a double mitral murmur of moderate intensity as well as a Grade III late apical systolic murmur heard all over the precordium, which became louder as one went to the left around the chest becoming maximum, Grade IV, posteriorly just under the angle of the scapula on the left. There was a palpable thrill transmitted to the left axilla and pulmonic region. There was no diastolic murmur. The heart was apparently in the left chest, with the point of maximum impulse 4 cm. to the left of the midclavicular line. Vital capacity 870-66 cc. Blood pressure 90/65.



FIG. 10.—Case 1. View of chest two and one-half months after operation, showing correction of deformity.

Roentgenologic examination of the heart showed it displaced entirely into the left chest by the thoracic deformity, the apex reaching almost to the left lateral chest wall. It did not appear to be enlarged. An electrocardiogram revealed the axis shifted to the right with the P waves inverted and diphasic.

Examination of the urine showed it to be normal. The red blood cell count was 4,460, white cell count 9,600. The nonprotein nitrogen was 12 mg., and the serum protein 6.8 per cent.

Operation—September 25, 1943. A vertical incision was made in the midline from the manubrium of the sternum to the upper abdominal wall. This was deepened down to the sternum. The xiphoid process was then freed-up and the attachments of the rectus muscle were freed from the costal margin and retracted. The sternal attachments



FIG 11—Case 2 Preoperative appearance of chest showing characteristic depression of lower portion of sternum

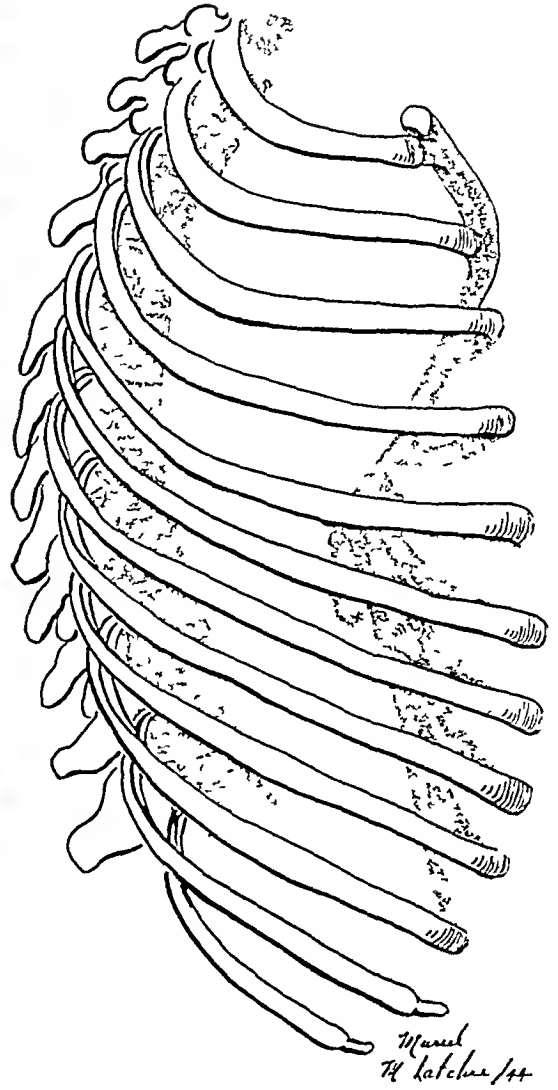


FIG 12—Case 2 Diagram of rib cage showing depth of sternal depression in this case

of the pectoralis muscles were then severed and retracted. The costal cartilages, beginning from below and working upwards, were then cut across about 1 cm from the sternum and division was carried up to the third cartilage on each side. The sternum was trimmed so as to free it of any costochondral attachments. A transverse osteotomy was performed with the rotary saw across the sternum just below the articulations of the third costal cartilages and a wedge-shaped piece of bone removed. The lower portion of the sternum was swung up and, using two wire sutures to close the gap where the wedge had been removed, the lower portion of the sternum was held in a new position, thus correcting the funnel deformity. Segments of cartilage were removed on each side so as to make the rib cartilages fit the sternum again and these cartilages were held to the sternum in its new location by means of heavy silk sutures.

Except for a urinary tract infection the patient's postoperative course was uneventful. Roentgenologic examination of the chest showed the heart still placed somewhat to the left. She was started on postural exercises before leaving the hospital and was to be followed in the Posture Clinic.

She was seen for a follow-up visit on November 19, 1943. The functional and anatomic results were excellent. She was gaining weight, her color was good, and she looked better than before operation. She was cooperating very well with her exercises, and gave a good demonstration of her deep breathing and postural correction. The scar was smoothly healed. An electrocardiogram, November 24, showed little change from the preoperative tracing except with respect to the P waves (at first

diphasic to inverted in leads 1 and 2), with slight axis deviation in all records. Fluoroscopy showed the heart still somewhat displaced into the left chest, but there was ample mediastinal space.

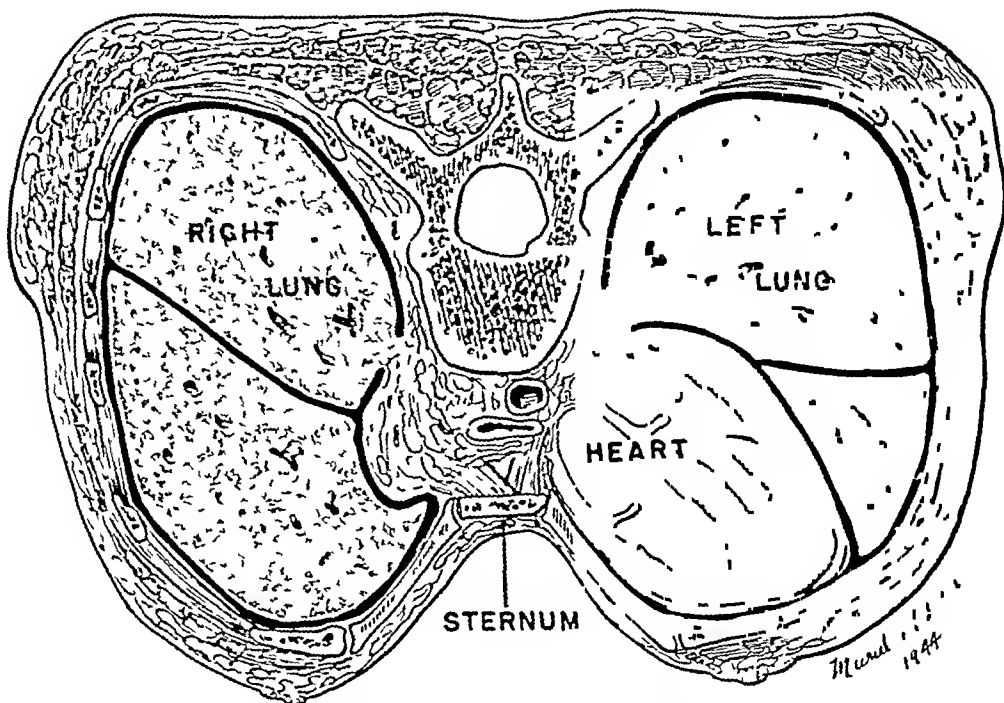


FIG. 13—Case 2. Diagram showing relations of the viscera and the chest wall deformity at the apex of the funnel-shaped depression. Note the heart pushed to the left but not so far as in Case 1.

TECHNICAL CONSIDERATIONS

In general the principles suggested by Doctor Brown were followed in the treatment of these two patients. The following minor departures from his method should be mentioned:

(1) A straight midline incision was used instead of the curved semicircular incision. This would seem to be preferable because it gives an exposure which is equally good on both sides of the sternum with a minimum of interference with the circulation to the skin edges.

(2) Excepting for the closure of the transverse osteotomy defect, heavy silk (No. 4 Deknatel) was used instead of wire to approximate the trimmed costal cartilages to the edges of the sternum. The silk gives adequate tensile strength and is more pliable.

(3) No external traction apparatus was employed to keep the sternum in place. Experience with these two cases demonstrates that this part of the procedure is not necessary.

(4) A light breast plate of plaster was made at the end of the operation in each case and moulded so as to fit the contour of the anterior chest wall over the gauze dressing. This was used to help stabilize the anterior chest wall during the first week after operation, during the time when there is such a great tendency to paradoxical motion of the chest wall during respiration. A plaster plaque such as was used in these cases has been found to be an invaluable assistance in the early convalescent-period after the opera-

tion of pericardiolysis and also after excision of a portion of the sternum for removal of tumors of that bone. It has been observed in such cases that the tissues assume enough rigidity of their own so that the plaster plaque can be abandoned after seven to ten days. In these two children the use of this



FIG. 14—Case 2. View of chest three months after operation showing correction of deformity.

support was beneficial and appeared to eliminate the necessity for temporary external traction.

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BRACHIAL PLEXUS BLOCK ANESTHESIA AN IMPROVED TECHNIC *

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THE INJECTION of local anesthetic agents into the brachial plexus for the production of regional anesthesia of the upper extremity is not new. Numerous descriptions,¹⁻²⁰ have appeared in both the foreign and American literature since the original description by Cline,¹ in 1897, of a painless amputation of the upper extremity using this type of anesthesia. Nevertheless, this procedure has not gained widespread use especially in this country as evidenced by the failure of the cumulative index to record an American article on this subject prior to 1927.² Furthermore, it was employed in only 25 instances at the Mayo Clinic in 1940.³ This lack of popularity is due to the frequent failure to obtain adequate anesthesia when the usual guide to the brachial plexus is used.

The landmark usually employed in reaching the brachial plexus, the midpoint of the clavicle, is not sufficiently accurate to insure contact with the plexus. Cases requiring anesthesia for a lesion of the upper extremity in which there also exists a contraindication to a general anesthetic are frequently encountered. This is especially true in injuries occurring in the Armed Forces. The purpose of this paper is to present a more accurate guide to the brachial plexus.

ANATOMY OF THE BRACHIAL PLEXUS

A study of the anatomy of the brachial plexus has been made in a series of neck dissections in postmortem specimens. These dissections showed a constant relationship between the anterior scalene muscle and the brachial plexus. Since this muscle is easily palpable in the neck, it should serve as an accurate guide to these nerves. Clinical application using this muscle as a guide has confirmed this impression. A total of 45 brachial plexus blocks has been carried out by five operators, with only three failures. This high incidence of successful anesthesia, 93 per cent, has been obtained by medical officers previously unfamiliar with this type of anesthesia. These results, we believe, are due to the relative ease with which the needle can be placed in contact with the brachial plexus when the anterior scalene muscle is used as a landmark.

The brachial plexus is formed by the lower four cervical nerves and a majority of the first thoracic nerve (Fig 1). The primary anterior divisions

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of these spinal nerves unite to form three trunks which emerge into the posterior triangle of the neck between the anterior and middle scalene muscles three or four centimeters above the clavicle. These muscles arise from the transverse processes of the cervical vertebrae the anterior scalene from the third fourth fifth and sixth, and the middle scalene from the transverse processes of the lower six cervical vertebrae. Each of these

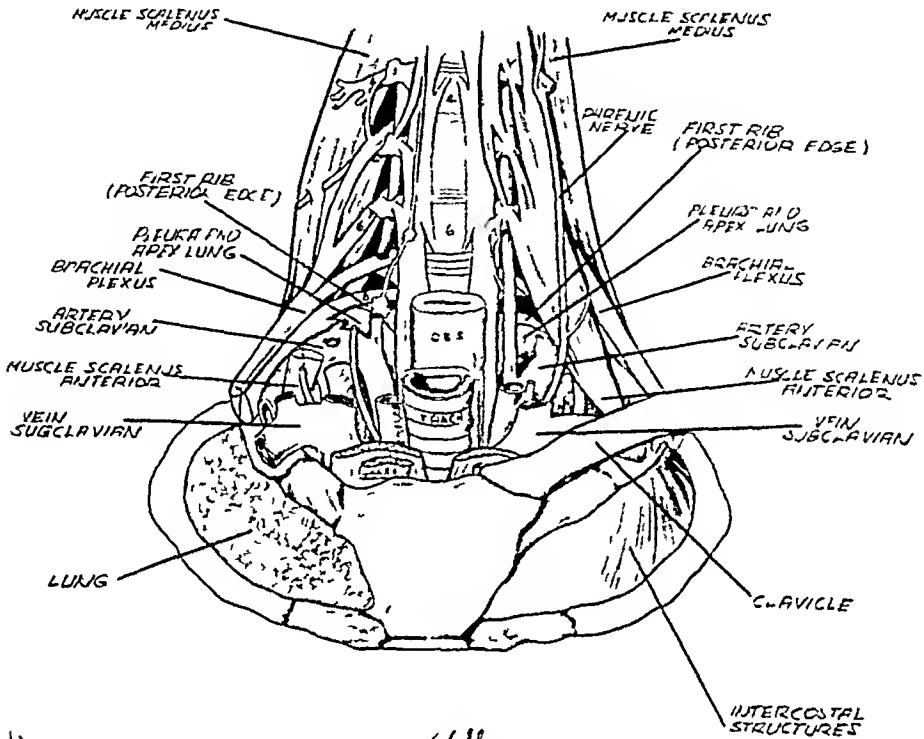


FIG 1—Anatomic sketch of an anteroposterior view of the neck illustrating the regional anatomy of the brachial plexus (Modified from Bailey, Surgery of Modern Warfare)

muscles is inserted into the first rib. The trunks of the plexus, namely the upper, middle, and lower, cross the middle third of the first rib and form an angle of approximately 23° with the lateral edge of the anterior scalene muscle. Thus, as these trunks pass through the posterior cervical triangle they remain relatively close to the lateral edge of this muscle. During their passage through the posterior triangle of the neck each trunk divides into two divisions preliminary to the formation of three cords. These cords are designated, lateral, posterior, and medial, according to their relationship to the subclavian artery. This artery also emerges between the anterior and middle scalene muscles just above their insertion into the last rib. The subclavian vein, however, lies anterior to the anterior scalene muscle, thus, the anterior scalene muscle separates the subclavian artery and vein (Fig 2). The cords of the brachial plexus accompany the subclavian artery beneath the clavicle into the axilla to the lower border of the pectoralis minor muscle where they divide into their terminal branches.

The anterior scalene muscle can be located in the posterior triangle of the neck just above the clavicle by palpation. If the patient's head is turned toward the opposite side, flexed toward the shoulder (Fig 3) and the fingers of the examiner's hand are drawn medially from the edge of the trapezius muscle just above the clavicle, a muscle mass will be felt just lateral to the clavicular head of the sternocleidomastoid muscle. The lateral edge of the most superficial muscle of this group, the anterior scalene, is the guide to the brachial plexus. The external jugular vein in most individuals runs from the

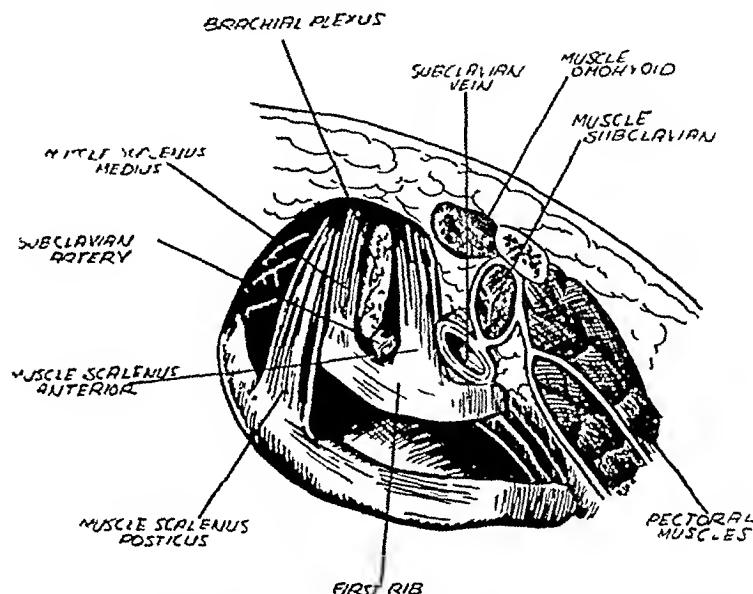


FIG 2—Anatomic sketch of a lateral view of the neck illustrating the regional anatomy of the brachial plexus and scalene muscles (Redrawn from Callander, Surgical Anatomy)

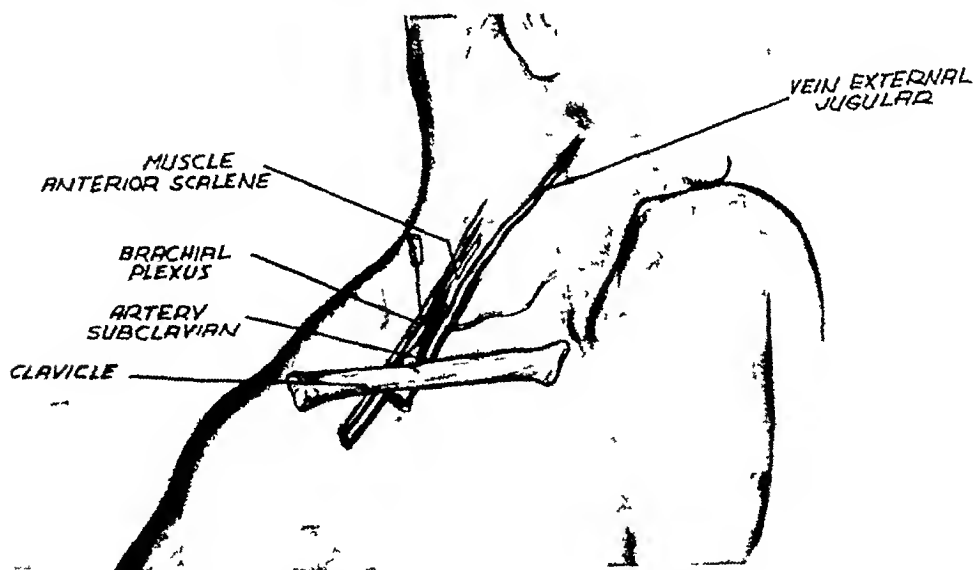


FIG 3—Sketch illustrating the relationships of the needle when properly inserted for injection of the brachial plexus. The position of the head is also demonstrated

angle of the mandible to the midpoint of the clavicle and usually lies over the anterior scalene muscle in the region of the clavicle. This serves as an additional aid in locating the anterior scalene muscle. In thin individuals the plexus itself can occasionally be palpated as it traverses the posterior triangle.

TECHNIC OF PROCEDURE

After surgical preparation of the skin, with the patient's head in the position noted above, the lateral edge of the anterior scalene muscle is identified by palpation. Approximately 2 cm above the clavicle, immediately over the lateral edge of this muscle, a small wheal is made in the skin with novocaine. An ordinary fine-caliber intravenous needle is inserted through the wheal and directed caudad, parallel to the midline, making an angle of from 30–45° with the skin of the neck (Fig 3). Contact with the plexus is manifested by paresthesia in the arm or hand. When the needle contacts the nerves of the brachial plexus muscular twitchings of the forearm and hand occur. In unconscious patients this twitching can be used to ascertain the proper location of the needle prior to the injection of the novocaine. As soon as the needle is in the proper position 15–30 cc of 2 per cent novocaine, containing 6 Mins of adrenalin to the ounce, are injected. Care must be taken that the needle does not become misplaced during the injection. We have found it unnecessary to attempt to inject the individual trunks, cords or nerves to obtain adequate anesthesia. It is recognized that the nerve supply of the skin of the proximal portion of the upper arm is not derived from the brachial plexus but from the intercostal nerves. If anesthesia of this area is necessary, one must encircle the upper arm with a subcutaneous injection of novocaine in addition to blocking the brachial plexus. Adequate anesthesia has resulted in 93.4 per cent of the cases in from 10–20 minutes. If the first rib is encountered without the production of paresthesia, the needle should be withdrawn and reinserted at a slightly different angle. Anesthesia is practically assured if definite contact with the plexus is made. The presence of the needle in the fascia surrounding the nerves is also evidenced by an increased resistance of the tissue to the needle. This resistance is easily recognized after a little experience. There is frequently, in addition to the above, a definite resistance to the injection of the solution. Occasionally when this resistance is marked, the patient will experience paresthesia during the injection.

We have found brachial plexus block well suited to a variety of surgical diseases of the upper extremity (Table I). It has been well suited to the surgical treatment of deep infections of the hand, in that it permits the use of a tourniquet and adequate exploration of the fascial spaces is possible. Its value in the treatment of fractures of the forearm and hand has been previously noted^{4, 5}. It is particularly indicated in these injuries when an experienced anesthetist is not available or when the reduction is to be aided by the use of the fluoroscope. In the latter instance the hazards of an unconscious patient in the darkened fluoroscopic room are avoided. In addition, this type of anesthetic is particularly well suited to the repair of severed tendons. Following the injection of novocaine around the nerves of the plexus pain is the first sensation to be abolished. This is subsequently followed by loss of the sense of touch. It is possible to have adequate anes-

TABLE I

Case No	Diagnosis	Operative Procedure	Operative Time* (Minutes)	Anesthesia
1	Chronic tenosynovitis	Excision tendon sheath	40	Complete
2	Fracture radius	Closed reduction	25	Complete
3	Ganglion, wrist	Excision of ganglion	75	Complete
4	Infected hand	Incision and drainage	30	Complete
5	Fracture, radial head	Manipulation and encasement	35	Complete
6	Chronic tenosynovitis	Excision tendon sheath	110	Complete
7	Onychitis mycotic	Onychectomy	45	Complete
8	Giant cell tumor of the tendon sheath	Excision of tumor	25	Complete
9	Chronic olecranon bursitis	Excision of bursa	27	Complete
10	Compound fracture finger	Debridement and reduction by skeletal traction	45	Complete
11	Severed tendon flexor profundus Fifth finger	Débridement and tenorrhaphy	80	Complete
12	Palmar abscess	Drainage of palmar abscess and exploration of thenar space	10	Complete
13	Burns arm	Débridement and pressure dressing	72	Complete
14	Laceration hand	Débridement	40	Complete
15	Giant cell tumor of the tendon sheath	Excision of tumor	30	Complete
16	Severed tendons	Tenorrhaphy	45	Complete
17	Severed tendons	Tenorrhaphy	105	Complete
18	Old severed tendons with scar fixation	Tenoplasty	175	Complete
19	Multiple verrucae hands	Fulguration		None
20	Chronic bursitis, olecranon	Excision of bursa	28	Paresthesia not produced
21	Chronic bursitis, olecranon	Excision of bursa	114	Unsuccessful
22	Dupuytren's contracture	Excision of palmar fascia partial	93	Required local infiltration of skin for closure
23	Severed tendons	Tenorrhaphy	55	Complete
24	Fracture ulna & radius	Closed reduction	35	Complete
25	Fracture ulna & radius	Insertion Haynes pins	45	Complete
26	Chronic bursitis olecranon	Excision of bursa	63	Complete
27	Severed tendon	Tenorrhaphy	33	Complete
28	Traumatic amputation third & fourth fingers	Débridement and closure	70	Complete
29	Fracture humerus	Haynes pin fixation	70	Complete
30	Gunshot wound, hand compound metacarpal fracture	Débridement reduction and encasement	65	Complete
31	Lumbrical abscess	Incision and drainage	15	Complete
32	Fixation scar of tendon	Tenoplasty	85	Complete
33	Scar fixation tendons of wrist	Tenoplasty	105	Complete
34	Ganglion wrist	Excision of ganglion	30	Complete
35	Crushed hand	Débridement and amputation first, second and third fingers	120	Complete
36	Crushed hand blast	Débridement	305	Complete
37	Abscess, hand	Incision and drainage	None	Paresthesia obtained
38	Denuded wound hand	Full-thickness skin graft	70	No anesthesia
39	Infected hand human bite	Débridement incision and drainage	None	Complete
40	Painful amputated stump finger	Reamputation finger	50	Paresthesia not obtained
41	Burns	Débridement pressure dressing	120	No injections
42	Burns	Débridement pressure dressing	120	Complete
43	Infected hand	Incision and drainage	15	Complete
44	Laceration hand	Debridement and repair	65	Complete
45	Ganglion wrist	Excision of ganglion	75	Complete

* Total duration of anesthesia was not determined, this represents the time in minutes adequate surgical anesthesia was present while in the operating room

thesia and the sense of touch persist. The complete loss of sensation, both pain and touch, precedes the loss of motor function. Partially retained motor power is a very valuable aid in matching severed ends of tendons prior to their suturing.

Aside from the humane point of view, the relief of pain is essential to the successful treatment of shock. Clinical evidence indicates that pain is a stimulus to both the development and depth of shock. The relief of pain is, therefore, a valuable therapeutic measure. Pain arising in the upper extremity can be completely and quickly relieved by a brachial plexus block. This relief is more prolonged and complete than that afforded by opiates, without the associated anoxia resulting from respiratory depression. The cleansing and debridement of burns of the upper extremity can be painless and more quickly carried out with anesthesia. This type of anesthesia has worked well in these cases. Likewise, brachial plexus block is indicated in extremely painful lesions of the arm while preparations are being made for definitive treatment. This is illustrated by Case 36, Table I. This patient suffered a badly mangled hand following an explosion, and, on admission, was in extreme pain and shock. In spite of active shock therapy his general condition did not improve until the pain had been completely relieved by a brachial plexus block. This individual had previously received a total of one grain of morphine without relief. Immediately following relief of the pain by the block he responded to shock therapy, and it was possible to debride and close the wound. No supplementary anesthesia was necessary although a total of 305 minutes elapsed between the initial injection of novocaine and the completion of the operative procedure. The excellent result obtained in this case suggests the value of this procedure in the combat zone. Soldiers suffering from painful injuries of the upper extremities can be completely relieved by brachial plexus block prior to their transfer from forward stations. The relief thus obtained should be more lasting than that produced by large doses of morphine. A small dose of opiate can then be given for its euphoric action without depressing the respiration.

In this series of 45 cases anesthesia was not obtained three times (6.6 per cent). Failure to obtain anesthesia is usually due to one of the following:

- 1 Inactive novocaine solution
- 2 Failure to use adrenalin in the solution, so that the novocaine is absorbed from the field before its fixation in the large nerve trunks. Braun⁶ states that prior to the use of adrenalin it was impossible to produce this type of anesthesia for this reason. In this series we have made no effort to confirm or disprove this statement.
- 3 Failure to inject the novocaine in contact with the nerves.

In one of our unsuccessful cases contact with the plexus was not made as evidenced by a failure to produce paresthesia. Novocaine was injected in the region of the first rib, as advocated by some operators^{3, 7, 8} but anesthesia did not occur. In another of our three failures paresthesia did not occur.

and no attempt was made to obtain anesthesia by blind injection around the first rib in this case. The other failure occurred after definite, unmistakable contact with the brachial plexus had been made. The cause for this failure was not apparent.

With all anesthetics there are certain dangers and secondary effects that must be constantly borne in mind if they are to be employed with a maximum of safety. Hartel and Keppler⁹ found phrenic nerve paralysis was a regular accompaniment of brachial plexus block. The phrenic nerve passes through the neck on the ventral surface of the anterior scalene muscle (Fig 1). Thus, it is relatively close to the field of injection and it is easy for the solution to spread to it. In this series, fluoroscopic examination performed after the operative procedure had been completed showed paralysis of the diaphragm in 20 per cent of the cases examined. In all instances the paralysis was temporary. In one instance, at the time of the fluoroscopic examination, there was a weakness of the diaphragmatic contractions, without a complete paralysis. Repeated fluoroscopic examinations on this patient revealed a complete recovery of the diaphragmatic movements before sensation returned in the arm. It is probable that paralysis of the diaphragm would have been found more frequently in this series of cases had the examination been made immediately after the injection rather than after the operative procedure was completed. It is certain that the paralysis is only transitory and is not as prolonged as the anesthesia. Hartel and Keppler, because of their findings relative to paralysis of the diaphragm, advised against a bilateral brachial plexus block. Strode⁴ performed a bilateral upper extremity amputation with this type of anesthesia and noted no ill effects. In this series an officer, suffering from burns of both upper extremities, was débrided and a Koch's pressure dressing applied, without evidence of respiratory embarrassment under bilateral brachial plexus block.

In the above group of cases there have been no complications and no side-effects noted other than the phrenic paralysis as mentioned. In a review of the literature, however, the following additional complications have been observed:

- 1 Temporary paralysis of the cervical sympathetic chain with the development of a typical Horner's syndrome¹⁰

- 2 Puncture of the dome of the pleura. It must be remembered that the pleura extends well above the first rib anteriorly (Figs 1 and 2). Puncture is manifested by pain and dyspnea if sufficient air is allowed to enter the pleural cavity through the open needle. In one reported case¹¹ death was attributed to this accident. The entry of air into the pleura can be prevented, if the needle is inadvertently thrust into it, by keeping a syringe attached to the needle during its insertion.

- 3 Novocaine reaction, though rare, must always be borne in mind when utilizing this drug. The preoperative preparation of the patient with barbiturates makes this infrequent complication even more unlikely. There

is more danger of the development of a novocaine reaction if the tip of the needle is in the pleural cavity at the time of injection due to the rapid rate of absorption of novocaine from the pleura

4 Anesthesia and paralysis persisted for three months in one reported case¹² Whether this was due to trauma to the plexus by the needle or to an increased sensitivity to the drug with severe nerve damage is not known

5 The accidental insertion of a needle into one of the great vessels has frequently occurred This complication was dreaded by physicians early in the use of local anesthetics It is now common knowledge that entry into a large vessel by a fine-caliber needle is a relatively innocuous procedure It should be pointed out that care must be taken to determine that the needle is not in a major vessel prior to the injection of the solution

SUMMARY

1 A new technic for injecting the brachial plexus to produce regional anesthesia of the upper extremity has been described

2 A table showing the nature of the lesions treated the types and duration of the operative procedures and the adequacy of the anesthesia have been included

3 The complications noted in this series of cases and those reported in the literature are discussed

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BASAL CELL LESIONS OF THE NOSE, CHEEK AND LIPS

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BASAL CELL LESIONS are most frequent about the nose, cheek and lip areas. Their study is not monotonous, however, because their etiology is variegated and the response of individual lesions to the different forms of therapy is far from uniform. Early lesions show hyperkeratoses of varying extent and flattened irregular nodular masses. If untreated they are apt later to become the so-called rodent ulcers. Most pathologists regard these tumors as growth derived from the lowermost or basal layers of the epidermis, for which reason they seldom show any tendency to keratinization or to pearl formation. Sections through such tumors show a complexity of downward-growing strands, all reaching to about the same level, sharply outlined against the stroma, and having very little inclination to strew cells into the irregular crevices of that tissue. This morphologic character is doubtless an expression of their relatively benign type of growth, and the rarity of any tendency to metastasize. Later on, however, necrosis and ulceration are common and the tumors often present themselves as slowly advancing ragged shallow ulcers with only a very thin wall of tumor tissue.

Etiologically, basal cell epitheliomata may start in some chronic growth or skin change, after an acute injury, after much exposure to strong light or to harsh winds and weather, as in the many cases occurring in farmers and sailors, after repeated roentgen ray treatments, such as for acne, or sometimes apparently spontaneously as a superficial red or pearly spot. Chronicity is usually an outstanding characteristic, but umbilication or ulceration may occur either early or late. In the occasional case *apparently* showing metastases to regional lymphodes or to some distant part of the body, a careful study will show that a squamous cell carcinoma has developed at the margin of a basal cell involvement and that the metastatic lesion is of squamous rather than of basal cell origin.

In early cases and in recurring ones in which the involvement and destruction have not been too extensive to make complete excision feasible, we prefer definite excision with the cold knife and such plastic repair as is adaptable to the situation. The recurrences are few and the cosmetic results are usually satisfactory.

It is true that many incipient and early basal cell lesions can be destroyed by caustics, cauterization, fulguration, desiccation, radium or roentgen ray

* Read before the Annual Conjoint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, Philadelphia, February 9, 1944

BASAL CELL CANCER OF FACE

To be safe by any method the destruction of the lesion must be complete. It is probable that both radium and roentgen ray are more efficient than caustics. The resulting defects from the use of some of the above-named methods are apt to leave more scarring than does a clean excision.

In basal cell lesions the fate of the patient rests largely on the judgment



FIG 1—H. R., age 57. Showing appearance of nose four years after excision of basal cell lesion with beginning ulceration (1.5×1.3 cm.) from midportion of left nasal ala. Surrounding tissues were freely undermined and immediately approximated. The lesion had been demonstrable for five years before operation.

of the physician in charge during the early stages of the growth and his mastery of the method of treatment he first elects to employ. Some of the recurrences occur in cases which have been classed in the "cured" group for more than five years.

I have no statistics on the percentage of recurring basal cell lesions which have been treated by the various methods, but my personal impression is that the vast majority of them have at some time received roentgen ray treatments. Those referred to us for plastic repair have usually had one or more recurrences, with repeated treatments. Often there has been considerable destruction of tissue and much fibrosis surrounding the area. The fibrosis is



FIG 2—D S, age 32. Showing appearance of tip of nose two years after excision of basal cell ulcer (1×1.25 cm) from tip of nose. Full thickness skin graft from postauricular region was immediately applied. (The lesion resulted from repeated roentgen ray treatments for acne)

a definite handicap in plastic repair because of the decreased blood supply. While the eradication of the basal cell area is of course, the primary consideration, the ultimate cosmetic appearance deserves careful consideration because of the psychologic and economic results. Thus, when it is found that the cells are not responding to radiation therapy as satisfactorily as expected, would it not be wiser, when the location of the lesion is favorable to utilize surgical excision and plastic repair while the surrounding tissues are not too fibrosed and still have an adequate blood supply?

In advanced cases with wide and deep ulcerations, which tend to recur soon after what is regarded as adequate radiation therapy, plastic reconstruction is usually not feasible. In such cases the use of suitable prostheses minimize the patient's mental depression and permit social contacts for varying periods of time.

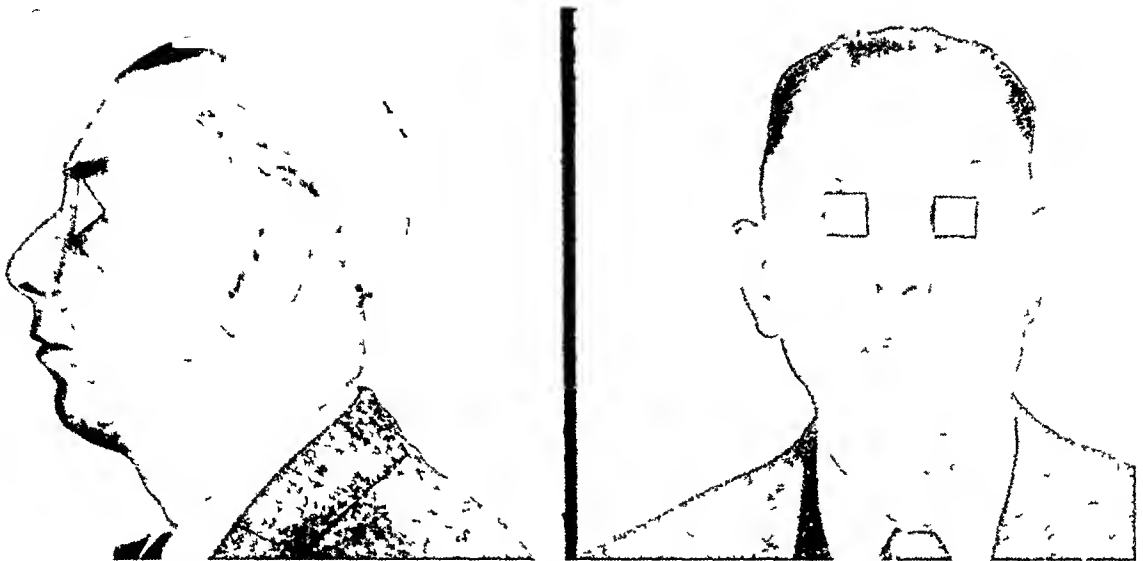


FIG 3—F. H.—4683, age 54. A and B. Appearance of left infra-orbital area one year after excision of basal cell ulceration (1.5 x 2 cm) and advancement of large triangular flap from the lateral nasolabial fold.

Lantern slides from gloss-finished unretouched photographs show the results obtained by the following procedures:

1. Excision followed by undermining surrounding skin and approximation of the margins (Fig. 1)
2. Excision and immediate full-thickness free skin graft (Fig. 2)
3. Excision and use of single pedicled flap from lateral nasolabial fold (Fig. 3)

4 A

4 B

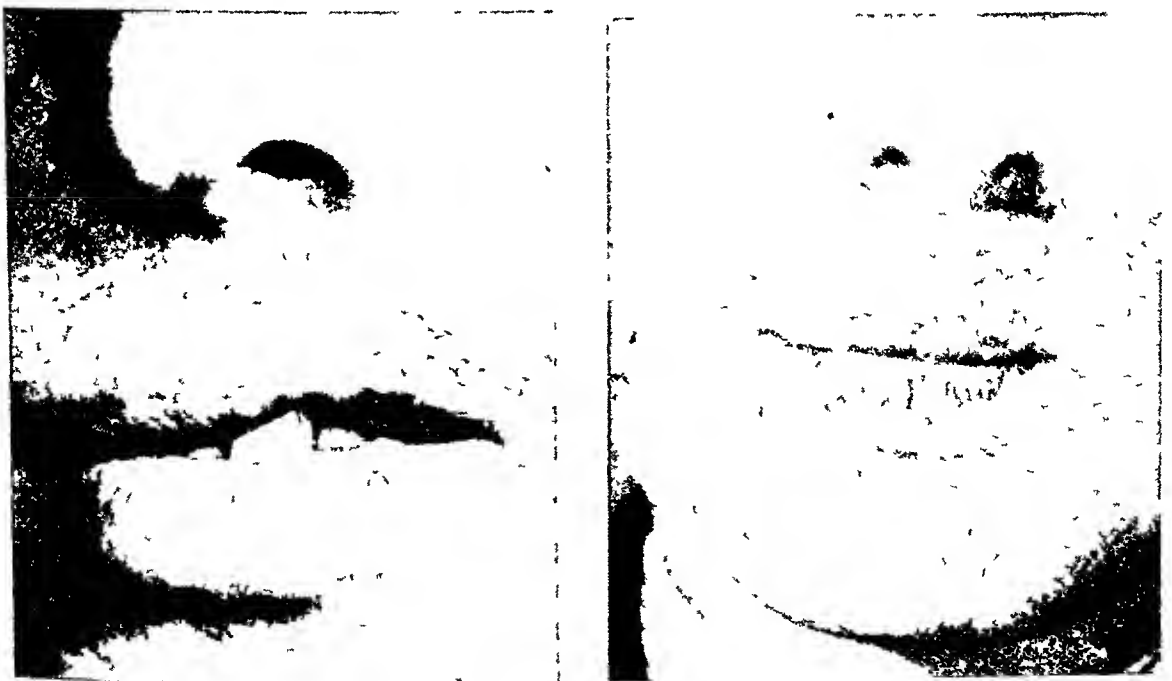


FIG 4—E. H.—6711, age 35.

- A. Basal cell lesion of lip. Result of roentgenray treatments for acne over a period of four years.
B. Appearance of lip two years after excision of over one-third of lip and advancement of flaps.

- 4 Excision and advancement of flap from lip and cheek (Fig 4)
- 5 Excision and use of delayed frontal pedicled flap, double epithelized (Fig 5)

5 A

5 B



FIG 5—T II—6331, age 60

- A Basal cell ulcerations of dorsum of nose of 28 years duration
 B Appearance of nose two years after excision of involved portion and reconstruction by use of double epithelized frontal flap

CONCLUSIONS

- 1 Basal cell lesions are characterized by their chronicity, slow local progress, absence of metastases to local or distant areas
- 2 The most important point in treatment is completeness of removal in the primary attempt—whatever method is employed
- 3 In early and moderately advanced lesions excision and plastic repair offer good chances for cure with minimum disfigurement
- 4 In late repeated recurrences with marked destruction of tissue, a prosthesis may be preferred to plastic procedures

EFFECT OF LOCALLY IMPLANTED SULFONAMIDES ON WOUND HEALING

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DURING THE PAST FEW YEARS there has been an increasing enthusiasm for the implantation of sulfonamides locally in wounds. The local use of sulfonamides has become so popular that many surgeons not only use it in cases that are likely to become infected, but they use it routinely in all of their operative wounds.¹⁻⁴ When an agent is used routinely in all operative procedures, it is the surgeon's duty to be absolutely certain that the agent employed does not do more harm than good. One way in which local sulfonamides might do harm is by interfering with wound healing. It has long been recognized that foreign bodies delay the healing of wounds. Although sulfonamide crystals apparently excite no specific type of cellular reactions in wounds, they must be regarded as foreign bodies and they do cause a foreign body reaction as long as they remain in the crystalline or powder form. Certain sulfonamides in high concentrations are known to be toxic to human cells. Jacoby, Medsker, and Willmer⁵ have demonstrated the toxicity of sulfanilamide and sulfathiazole to human cells in tissue cultures. Reed, Orr and Anderson⁶ have shown that sulfathiazole in high concentration inhibits the growth of fibroblasts. This toxicity is recognized by a suppression of growth and lack of multiplication of fibroblasts, macrophages, and epithelial cells.

Opinions differ as to the actual effect of sulfanilamide and sulfathiazole on wound healing. Bucker and Graham⁷ reported that systematically administered sulfanilamide interferes with wound healing. This was contrary to the findings of Zintell, *et al.*⁸ who found that systemic sulfanilamide and sulfadiazine did not interfere with wound healing. Taylor⁹ feels that the use of all sulfonamides when implanted locally in wounds produces such profound inflammatory reactions that their employment is not justified. Bick¹⁰ reported that, in his experience, the use of sulfonamides locally in primary sutured wounds of the soft parts retarded wound healing by at least 50 per cent of the time factor, and that they caused extensive cutaneous scarring. On the other hand, Glynn¹¹ reported that sulfathiazole and sulfapyridine inhibit fibroblastic proliferation, and that sulfanilamide and sulfapyridine have a definite toxic action on striped muscle, but that these effects are not sufficient to contraindicate the use of these drugs. Harbison and Key,¹² and Key⁴ have reported that the local implantation of sulfanilamide and sulfathiazole in moderate amounts does not interfere with wound healing. Taftel and Harvey¹³ have reported that systemically administered sulfanilamide did not retard the healing of stomach wounds in rats. Considering

the apparently conflicting reports, it seemed appropriate to repeat the experiments using sulfanilamide and sulfathiazole locally in uninfected wounds. In the experiments mentioned, no attempt was made accurately to control the amount of sulfonamide placed in the experimental wounds. In this experiment the amount of sulfonamide deposited in the wound was carefully controlled. The amount used was equivalent to one gram for each ten square inches of wound surface.

Measurement of the degree of wound healing resolves itself into three main phases, namely: Clinical course, including the resultant cosmetic effect of the degree of scarring, tensile strength, and histologic structure of wounds during the course of healing. The reported clinical observations have not been generally satisfactory because of the lack of an adequate number of control cases. Few surgeons have been willing to use alternate cases as controls. The data published here are from experimental wounds in animals. In such wounds not only the clinical course but also the tensile strength, and histologic structure can be studied through the entire period of wound healing. Measurement of the tensile strength and microscopic studies during the period of wound healing, offer a more direct method of evaluating the degree of wound healing.

The purpose of this experiment was to test the effect of locally implanted sulfanilamide and sulfathiazole on wound healing. Both the microcrystalline* and the macrocrystalline forms of sulfathiazole were used. Uniform amounts of these agents were used. It is well known that large amounts of sulfonamides in wounds not only cause caking of the sulfonamides, but also cause serum collections which interfere with wound healing.

Four groups of 12 rats each were used. The first group was the control group. The second, third and fourth groups had implanted in their wounds, sulfanilamide, microcrystalline sulfathiazole and macrocrystalline sulfathiazole, respectively. Incisions exactly four centimeters long were made through the entire thickness of the abdominal wall four millimeters lateral to and parallel to, the linea alba. After closing the peritoneum and transversalis muscle with a continuous suture of plain No. 00000 catgut to amount of sulfonamide equivalent to one gram per ten square inches of wound surface was placed in the wound. Thus, the amount deposited in a wound four centimeters long in an abdominal wall three millimeters thick, was 37 milligrams. The crystals were spread as evenly as possible over the wound surface. The remaining muscular and fascial layers of the abdominal wall were closed with a continuous plain No. 000 catgut suture. Approximation of the skin was by means of interrupted silk sutures. Treatment of the control animals was exactly the same except that no sulfonamide was introduced into the wounds.

* Provided by Smith, Kline, and French, Inc. The so-called microcrystalline sulfathiazole has a particle size of five to six microns as compared with a particle size of 30 microns for the ordinary sulfathiazole preparations here called macrocrystalline sulfathiazole.

LOCALLY IMPLANTED SULFONAMIDES

Three animals of each of the four groups were sacrificed on the 4th, 8th and 12th postoperative days. After the removal of the silk sutures the tensile strength of the entire thickness of the abdominal wall was determined by means of the tensiometer, as described in previous publications by Meade¹¹ and Zintel.⁸ Blocks of tissue were prepared for microscopic study of all the wounds.

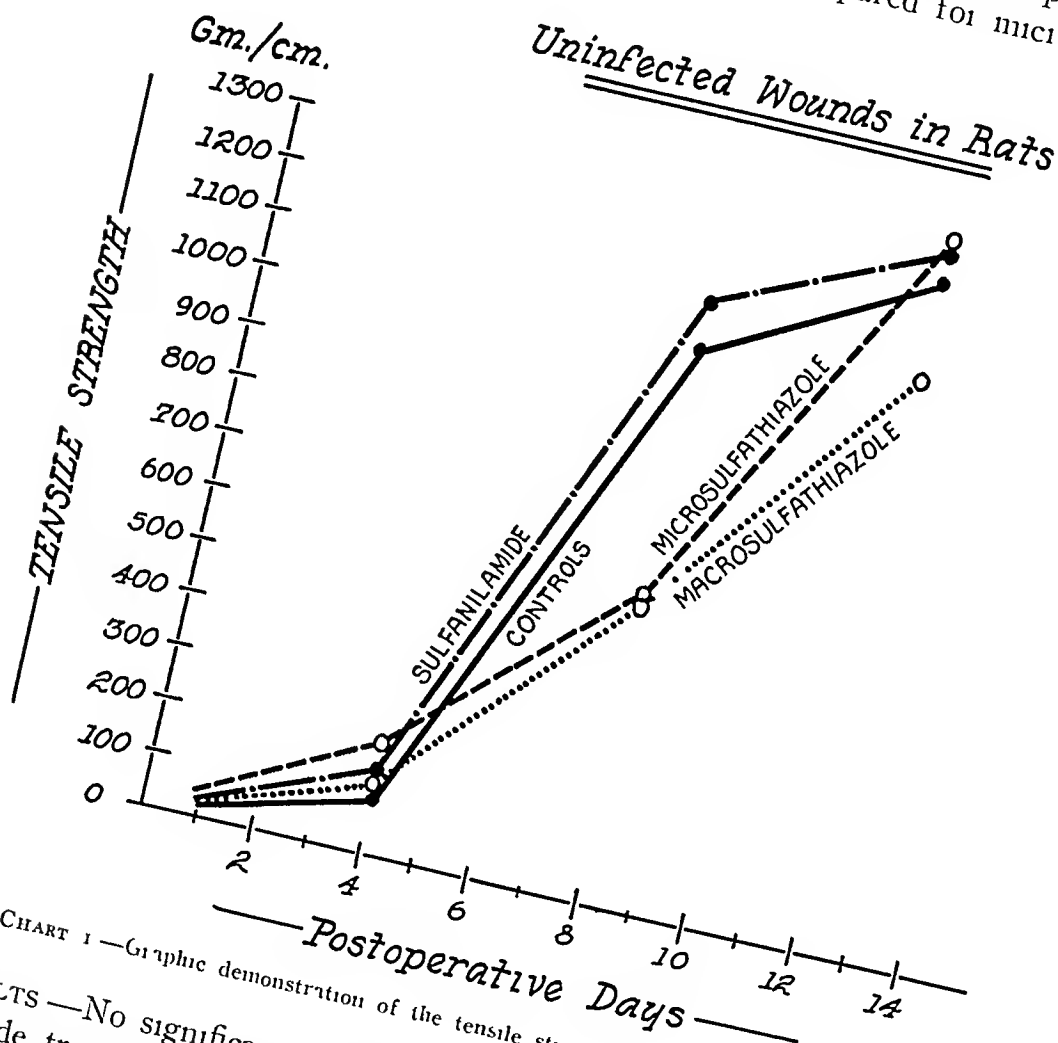


CHART 1—Graphic demonstration of the tensile strengths of the various groups

RESULTS—No significant difference was noted histologically between the sulfonamide treated wounds and the control wounds. Evidences of slight infections occurred with equal frequency in both the experimental and the control animals. The reaction around the remaining fragments of catgut did not vary from one group to the other. Microscopically, no significant difference was noted in the incidence or degree of infection, in the reaction to catgut, in the extent of fibroplasia, or in the degree of epithelization. The tensile strengths of the various groups are shown graphically in Chart 1. Four days after operation there was no difference in the tensile strengths of the control and sulfonamide-impregnated wounds. On the eighth postoperative day the tensile strengths of the wounds that were treated with sulfathiazole (both the macrocrystalline and the microcrystalline forms) were definitely less than the tensile strengths of the control and sulfan-

lamide-treated wounds At the end of 12 days the tensile strengths of the wounds in all groups were normal except the group which was impregnated with macrocrystalline sulfathiazole The macrocrystalline sulfathiazole-impregnated wounds were not so strong as the wounds of the control animals on the 12th postoperative day

Sulfanilamide, therefore, when implanted in wounds in amounts equivalent to one gram per ten square inches of wound surface, did not retard wound healing Wounds impregnated with an equivalent amount of the ordinary form of sulfathiazole were definitely weaker than the wounds of the control and sulfanilamide-impregnated wounds Wounds impregnated with microcrystalline sulfathiazole were not so strong as the control animals on the eighth day, but these wounds attained normal strength on the 12th postoperative day

A possible explanation of the fact that sulfathiazole inhibits wound healing when applied locally, and that sulfanilamide does not significantly inhibit wound healing, lies in their difference of solubility Both substances have been shown to be toxic to human cells in tissue cultures Sulfanilamide being the more soluble of the sulfonamides tested, disappears from wounds quite rapidly Sulfathiazole being less soluble, remains in wounds longer and therefore, exerts its toxic action and causes a foreign body reaction for a longer period of time This period is apparently prolonged enough to delay healing of the normal wound The microcrystalline form of sulfathiazole is more readily soluble than the ordinary macrocrystalline sulfathiazole by reason of its greater surface area Apparently the "toxic" action following the implantation of microcrystalline sulfathiazole is sufficiently prolonged to interfere with the tensile strength of healing wounds on the eighth postoperative day, but it is not sufficiently prolonged to interfere with wound healing at the end of 12 days The detrimental effect of macrocrystalline sulfathiazole is still apparent at the end of 12 days suggesting that the microcrystalline form is better tolerated than the macrocrystalline form of sulfathiazole The results here reported would indicate that sulfathiazole should not be implanted into operative wounds if maximal wound healing is desired Sulfanilamide crystals do not interfere with wound healing when evenly applied to wounds in amounts equivalent to one gram per ten square inches of wound surface

CONCLUSIONS

- 1 It has previously been demonstrated that sulfonamides are toxic to some human tissue cells
- 2 Our previous experiments indicate that therapeutic concentrations of systemically administered sulfanilamide and sulfadiazine do not interfere with the healing of the uninfected wound
- 3 Sulfanilamide in amounts equivalent to one gram per ten square inches of wound surface does not interfere with normal wound healing
- 4 Microcrystalline sulfathiazole (particle size five to six microns)

LOCALLY IMPLANTED SULFONAMIDES

implanted locally in wounds, produces wounds with a decreased tensile strength at eight days, but the tensile strength of these wounds is normal at the end of 12 days

5 Macrocrystalline sulfathiazole, the commonly used form of sulfathiazole, causes a delay in wound healing which is apparent even at the end of 12 days

The author wishes to acknowledge assistance from Dr. Souther Tompkins during a portion of this study

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ANESTHETIC DEATHS IN 54,128 CONSECUTIVE CASES

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IN AN ENDEAVOR to evaluate the safety of the various anesthetics in our hands we have analyzed all cases of sudden death occurring on the operating table at Duke Hospital during a 12 5-year period. The difficulty in assessing the part played by the anesthetic in the death of a patient during or following operation is well known and the difficulty increases in proportion to the time elapsing between the operation and the patient's demise. We have limited our study, therefore, to those cases in which death occurred during or shortly after operation.

From July 1, 1930, to January 1, 1943, a total of 54,128 anesthetics were administered for all types of operative procedures. During this period 38 patients died during operation or a few minutes thereafter (Table I). Twenty-seven deaths which are ascribed to the anesthesia (Table II) occurred during general or spinal anesthesia. Some of the patients undoubtedly would have succumbed sooner or later to the existing disease but the anesthesia could not be completely exonerated as the immediate cause of death.

TABLE I

Anesthetic	Total No of Anesthetics	Total No of Sudden Deaths	No. Per 1000 Anesthetics	Anesthetic Deaths	No. Per 1000 Anesthetics
Ether	14,724	6	407	6	407
Cyclopropane	5,744	7	1.21	4	691
Cyclopropane with ether	393	0	0	0	0
Nitrous oxide	6,705	4	590	2	295
Nitrous oxide with ether	2,175	2	919	2	919
Ethylene	6	1		1	
Chloroform	9	0	0	0	0
Vinethene	266	0	0	0	0
Vinethene with ether	326	0	0	0	0
Avertin	261	1	3.83	1	3.83
Avertin with supplement	1,615	6	3.71	3	1.85
Sodium pentothal	1,006	1	99	0	0
Sodium pentothal with nitrous oxide	226	0	0	0	0
Evipal	48	0	0	0	0
Spinal	5,436	6	1.10	6	1.10
Spinal with supplement	930	2	2.15	2	2.15
Caudal	1,106	0	0	0	0
Local	13,151	2	150	0	0
Sodium amytal	4	0	0	0	0
Total	54,128	38	702	27	498

ANESTHETIC DEATHS

TABLE II

CAUSE OF DEATH IN 38 CASES OF SUDDEN DEATH ON THE OPERATING TABLE

Shock	2	
Hemorrhage	2	
Infection	5	
Medullary compression	2	
Asphyxia due to aspiration of vomitus	1	} Anesthetic deaths
Unknown	26	
Total	38	

TABLE III

ANALYSIS OF ANESTHETIC DEATHS IN 39,880 CASES OF GENERAL AND SPINAL ANESTHESIA

	Case	Age	Sex		Race		Operative Risk		Autopsy
			Male	Female	White	Colored	Good	Poor	
Ether	1	50		+	+		+		0
Ether	2	2	+		+		+		0
Ether	3	8	+		+		+		0
Ether	4	7 wks		+		+	+		0
Ether	5	21	+			+	+		0
Ether	6	30	+			+	+		+
Cyclopropane	7	11		+		+	+		+
Cyclopropane	8	17	+			+	+		0
Cyclopropane	9	17	+			+	+		+
Cyclopropane	10	26	+		+			+	0
Nitrous oxide	11	49	+			+		+	+
Nitrous oxide	12	55	+			+		+	+
Nitrous oxide ether	13	36		+		+		+	+
Nitrous oxide ether	14	29		+		+		+	0
Ethylene	15	28		+		+		+	+
Avertin	16	25	+			+		+	+
Avertin-ether	17	20		+		+	+		0
Avertin-ether	18	33	+			+	+		+
Avertin-ether	19	16	+			+	+		0
Spinal	20	37	+		+			+	0
Spinal	21	50		+		+		+	0
Spinal	22	31	+			+		+	+
Spinal	23	62	+		+			+	+
Spinal	24	39	+			+		+	0
Spinal	25	53		+	+			+	0
Spinal with supp	26	41		+	+			+	+
Spinal with supp	27	63	+		+			+	0
Total	27		17	10	9	18	12	15	12

Eighteen of the 27 deaths, or 66 per cent, were in Negroes (Table III). This is significant in view of the fact that less than 15 per cent of the total number of patients undergoing operation annually at this hospital are Negroes. The explanation for this high mortality rate probably lies in the difficulty of judging the degree of cyanosis in colored individuals and in the poorer general condition of the average Negro as contrasted to the average white patient in the Duke Hospital.

It is interesting to note that of the six patients (Cases 1-6) who died during ether anesthesia (Table III) four were receiving ether through oral catheters and three of the latter were undergoing operations upon the eye. The combination of draping necessary for eye operations and the administration of ether vapor through a catheter makes it difficult for the anesthetist to judge the depth of anesthesia and the degree of cyanosis. The deaths

except for one due to aspiration of vomitus, probably were due to overdosage. In 2,200 cases of general anesthesia, excluding cyclopropane, Schmidt and Waters¹⁰ report two anesthetic deaths, one of which occurred during an eye operation in which the patient was receiving ether through an endotracheal catheter.

TABLE IV
COMPARATIVE STUDY OF ANESTHETIC DEATHS

Anesthesia	From the Literature*	Total No of Cases	Anesthetic Deaths	No Per 1 000
General and spinal	{ Schmidt & Waters ¹⁰	4 400	3	681
	{ Dealy ⁴	19 529	18	921
	{ Duke Hospital	29 880	27	677
Cyclopropane	{ Schmidt & Waters ¹⁰	2 200	1	454
	{ Sahler <i>et al</i> ⁹	7 120	0	0
	{ Taylor ¹¹	39 284	10	254
	{ Duke Hospital	5 744	4	691
Avertin with supplement	{ Beecher ¹	3 934	7	1 78
	{ Mueller ⁸	5 000	0	0
	{ Duke Hospital	1 615	3	1 85
Spinal	{ Dealy ⁴	3 193	7	2 19
	{ Veal & Van Werden ¹³	33 811	30	887
	{ Duke Hospital	6 366	8	1 25

* No really accurate comparison of statistics is possible since there are such wide variations in nutritional states, conditions requiring operation, color (the anesthetic death rate is over ten times greater in the colored than in the white patients in the Duke Hospital), distances traveled, etc.

Autopsy performed upon the patient who died during hemorrhaphy (Case 6) revealed a partial occlusion of the right coronary artery by a sclerotic plaque. Follis⁷ reports three consecutive cases of sudden death during nitrous oxide-oxygen-ether anesthesia in which a similar condition was found.

Two deaths in our *cyclopropane* series (Cases 7 and 9) appear to have been due to overdosage and in another (Case 8) overdosage could have been responsible for death. At autopsy one patient (Case 7) was found to have a "granulomatous myocarditis," the significance of which is unknown. In retrospect, the choice of anesthesia for the patient with thyrotoxicosis (Case 10) was poor in view of the likelihood of the occurrence of ventricular fibrillation in this condition following the administration of cyclopropane.²

Both patients who died while receiving *nitrous oxide* were classified as poor operative risks. Perhaps an anesthetic permitting the use of a higher percentage of oxygen would have been a better choice for the individual with pulmonary tuberculosis (Case 11). There is still some disagreement over the choice of anesthesia in Ludwig's angina (Case 12). Trout¹² favors pentothal or ethylene, but adds that the surgeon should be ready to perform an emergency tracheotomy before the anesthesia is started and should stand by during the induction of the anesthesia. Bennett¹ recommends intratracheal intubation before operation. If this can be done any anesthetic agent is satisfactory.

The patients who expired while receiving a mixture of nitrous oxide-oxygen-ether (Cases 13 and 14) were poor operative risks, and it is difficult to say whether another type of anesthesia would have been a better choice.

Our experience with *ethylenc* has been too limited to warrant comment. The one death (Case 15) is included in this study although shock appears to have been the more likely cause of death.

It is doubtful whether the patient who died under *avertin* anesthesia (Case 16) could have withstood the operation under any other type of anesthesia.

Avertin supplemented with ether has proved to be the most dangerous of all anesthetics in our hands. Three deaths have occurred in young adults considered good operative risks (Cases 17-19). The dangers of *avertin* used alone or as a basal anesthetic are generally recognized,¹ and in our experience its disadvantages appear to outweigh its advantages, its use therefore, at the Duke Hospital has been discontinued except for an occasional case.

All deaths which occurred during spinal anesthesia at this hospital were in patients judged poor operative risks who were undergoing emergency abdominal operations (Cases 20-27). Perhaps the high mortality rate could be bettered by the judicious administration of fluids and careful continuous observation of blood pressure. At the present time special care is taken to insure constant blood pressure observation, and it is routine for intravenous fluids to be administered during all operative procedures of any length requiring a general or spinal anesthesia. Despite the high immediate mortality experienced when employing spinal anesthesia in emergency abdominal surgery, there are certain conditions which some feel demand this type of anesthesia. Graham and Brown⁷ feel strongly that if adequate facilities are available spinal anesthesia should be used for all operations for acute intestinal obstruction. Foss and Bush⁶ believe the risk of spinal anesthesia in cases where there is likelihood of extensive trauma to the viscera under general anesthesia is more than offset by the decreased risk resulting from the lessened visceral trauma made possible by the more complete relaxation. These views are opposed by Wangenstein,¹⁴ however, who feels that in spite of certain advantages afforded by spinal anesthesia inhalation anesthesia offers the greatest safety to the patient suffering from intestinal obstruction.

SUMMARY

1 During 54,128 anesthetics of all types there have been 38 sudden deaths, or 0.702 per 1,000.

2 Twenty-seven so-called "anesthetic" deaths have occurred during 39,880 general and spinal anesthetics, or 0.677 per 1,000.

3 Two-thirds of the "anesthetic" deaths occurred in Negroes although

less than 15 per cent of the total number of patients undergoing operation annually at the Duke Hospital are Negroes

4 If the ages and preoperative conditions of the patients who died are taken into consideration in evaluating the results, the most dangerous agents in our hands have been avertin-ether, with a death rate of 1.85 per 1,000 and cyclopropane, with a rate of 0.691 per 1,000

5 The administration of ether through an oral or tracheal catheter to patients whose faces are obscured by heavy drapes is a dangerous practice

6 Spinal anesthesia in debilitated, acutely ill patients with low blood pressure may hasten the end, but offers certain advantages not found in other types of anesthesia

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BRIEF COMMUNICATIONS

TRAUMATIC RUPTURE OF THE GALLBLADDER

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TRAUMATIC RUPTURE of an apparently normal gallbladder is a very rare injury, but such a case was admitted to the Surgical Service, Good Samaritan Hospital, January 30, 1944. Frankly, it was not recognized as such until operation, 40 hours later. The outstanding difference between it and rupture of the other viscera we have seen, was the absence of any early signs of shock or of an acute surgical abdomen. In the past year we have been actively associated with cases of traumatic rupture of the spleen, kidney, liver, and small bowel (ileum), and in all these cases the onset of acute signs and symptoms was rapid.

Survey of the literature reveals less than 50 reported cases of traumatic rupture of the gallbladder from a blow on the abdominal wall. In fact, most of the earlier reported cases were never proved by operation or autopsy—simply diagnosed by aspirating quarts of bile, associated with peritonitis following abdominal injury. In these cases, also, the appearance of the acute surgical abdomen was slow, and the degree of shock varied according to the type and severity of the accident.

The case presented herewith is especially instructive as it was masked by intoxication. The patient being noisy and apparently not much hurt was almost not admitted to the hospital, as it was midnight and the admitting office did not wish to disturb the ward patients.

Case Report—L. H., male, age 28, had been drinking rather heavily and ran his automobile into a tree. Presumably, he struck his upper abdomen against the steering wheel. He was brought from the scene of the accident to the hospital. The patient was noisy and non-cooperative, complained of no particular pain, and showed no signs of injury except a few scratches and slight contusions. Fortunately, the Resident ordered him put to bed, and he finally fell asleep after three hours, with the aid of sedatives.

He was still sound asleep the next morning, and as his T, P, R were practically normal he was not disturbed. Later in the day his condition was reported as satisfactory, his only complaint being some abdominal soreness. The following morning, however, he was definitely sicker and his abdomen was becoming tender and somewhat rigid. The W, B, C and polymorphonuclears were elevated. He had no nausea or vomiting and no blood in urine or stools. By afternoon his condition had become worse, Temperature 102.4° F, W, B, C 25,000, polys 88 per cent. Lungs clear. Immediate operation was performed.

Operation—Under spinal anesthesia, a right rectus incision was made part above and below the umbilicus. At once we remarked the yellow color of the peritoneum, and on incising it much free bile escaped. Careful exploration revealed no abnormalities until the finger entered what seemed to be the gallbladder. The incision was prolonged upward and the gallbladder exposed, revealing a rent 3 cm long in the fundus on the side adjacent to the liver. The gallbladder appeared normal otherwise, and there were no signs of injury to the liver or bile ducts. The tear was sutured and sulfanilamide powder was sprinkled about it. One cigarette drain was placed in the abdomen in closing.

The patient had moderate distention and fever for 48 hours, and slight drainage of bile for 96 hours, but otherwise made a rapid, uneventful, and excellent recovery.

BOOK REVIEW

SURGICAL ERRORS AND SAFEGUARDS By Max Thorek, M D , LL D , D C M , F I C S
With a foreword by Sir Hugh Devine, M S , Hon F R C S (Eng), F R A C S ,
F A C S (Hon), and a chapter on Legal Responsibility in Surgical Practice by Hubert
Winston Smith, A M , M B A , L L B , M D , 4th ed Philadelphia, Montreal, and London
J B Lippincott Co , 1943

The new edition of Doctor Thorek's "Surgical Errors and Safeguards" has been entirely reset and considerably enlarged. The fact that it is issued as a fourth edition indicates that it has found a wide field of usefulness to the medical profession. It is particularly opportune that the fourth edition comes at this time. With the intern and resident system placed on a "9-9-9" basis there will be very little opportunity for the recent graduate to acquire a reasonably complete hospital training. There will be large gaps in the teaching program and very little time for a first class clinical experience. Therefore, a text-book that presents in an incisive fashion the possible errors and complications in diagnosis, preoperative, operative technic, and postoperative treatment, is more than welcome. The book itself is encyclopedic in scope, with many and extensive quotations from current surgical literature. A very complete and detailed index makes it possible for the student to have quick access to the particular problem that may be presented to him.

The text is presented in the form of innumerable paragraphs and does not lend itself for continuous reading. However, the intent of the author is not to write a discursive book on surgery but to indicate the high points of technical surgery, both from his own personal experience and that of others. At the end of each chapter is an extensive reference to the sources of the material. This feature should be of great value to the group of young men who will become the surgeons of the future. The selection and the quality of the material are on the whole excellent and the general tenor of the bibliography is to round out the high points of the preceding text.

The reviewer has very few criticisms. It would seem wise, however, for any future editions to submit the text and illustrations to a more critical selection. There are numerous illustrations that have no relationship to the text and aside from being reproductions of photographs have very little value. The inclusion of many of the statistical quotations is redundant and could well be omitted.

Section 19, "Legal Responsibility for Surgical Practice Based on Legal Doctrine in the United States and Great Britain," by Mr Hubert Winston Smith of the Harvard Law School, is a valuable addition. The doctor in his professional capacity may commit one of several torts recognized by law and render himself liable to a civil action for damages. The contribution of Mr Smith is presented briefly and with lucidity and projects the many intricacies of the law in relationship to the practicing surgeon.

It is a great pleasure to read the foreword by so eminent a surgeon as Dr Hugh Devine of Melbourne, Australia and the reviewer subscribes to this statement from the foreword "This book is written with the intention to help, much as a surgeon father would wish to help a surgeon son, and as the guilds of the Middle Ages passed on their secrets from generation to generation."

The fourth edition of Doctor Thorek's "Surgical Errors and Safeguards" is an excellent book. It undoubtedly fulfills the purpose for which it is designed and is a credit both to the author and the publishers. The reviewer recommends it.

CHAS GORDON HEYD, M D

INDEX TO VOLUME 119

A

- Abdominal Aorta, Ligation of the, for Aneurysm, 457, Wall, Chronic Progressive Gangrene of the, 796, Wall Cyst, Paraumbilical, 279
- ABELS, JULES C, *et al* Metabolic Studies in Patients with Cancer of the Gastrointestinal Tract XXII—Estimation and Significance of Blood Loss During Gastrointestinal Surgery, 865
- Abscess and Phlegmon, Acute Retroperitoneal, 741
- ACKMAN, DOUGLAS A Report on the Management of Burns, 161
- Acute Perforation in Gastroduodenal Ulceration With Special Reference to End results, 321, Acute Retroperitoneal Abscess and Phlegmon, 741
- Adenomatosis of Islet Cells, With Hyperinsulinism, 824
- Adenoma, Total Pancreatectomy for Hyperinsulinism Due to an Islet cell, 211
- ADOLPH, PAUL E, Maj, MC Experiences in War Surgery in China, 134, Preoperative Measures Used in War Surgery in China with Special Reference to the Delimiting Tourniquet, 246
- Afferent Vasodepressor Nerve Impulses as a Cause of Shock Tested Experimentally by Aortic Depressor Nerve Stimulation, 26
- ALM, THEODORE Studies on Traumatic Shock I—Blood Volume Changes in Traumatic Shock, 64
- Amino acids (Amigen), Special Reference to the Oral Use of in Three Cases, in the Nutritional Care of Cases of Extensive Burns, 815
- Anatomic Study of the Lumbosacral Region in Relation to Low Back Pain and Sciatica, 892
- ANDRUS, WILLIAM DEW Further Experience with the Treatment of Burns with Sulfonamide Impregnated Membranes, 694
- Anesthesia, Brachial Plexus Block An Improved Technique, 935, in Surgery, Refrigeration, 178
- Anesthetic Deaths in 54, 128 Consecutive Cases 954
- ANNOUNCEMENT, 480, Advisory Board for Medical Specialties, 288, The Samuel D Gross Prize, 800
- Annular Pancreas Producing Duodenal Obstruction, 759
- Aorta, Abdominal, Ligation of the, for Aneurysm, 457
- ARCHER, H L Clinical and Laboratory Experiences with Succinyl Sulfathiazole, 518
- ARNHEIM, ERNEST E Acute Retroperitoneal Abscess and Phlegmon, 741
- Atresia of the Esophagus, Congenital, With Tracheoesophageal Fistulae, 556

B

- BALL, ROBERT P, *et al* Thyroid Carcinoma with Metastases Studied with Radioactive Iodine, 668
- BARCHAN, I, *et al* The Nutritional Care of Cases of Extensive Burns With Special Reference to the Oral Use of Amino acids (Amigen) in Three Cases, 815
- Basal Cell Lesions of the Nose, Cheek and Lips, 944
- BEAL, JOHN M Lymphosarcoma of the Gastrointestinal Tract, 108
- BENNETT, B A Acute Perforation in Gastroduodenal Ulceration With Special Reference to End results, 321
- BERK, J EDWARD, Capt, MC Hypertrophic Pyloric Stenosis in Adults, 124
- Bile Duct, Surgical Indications in Diseases of the Common, 384
- Bile Ducts, A Rare Abnormality of the The Antoduodenal Position of the Cystic Duct, 774
- Bladder, Diverticula of the Urinary, 656
- BLALOCK, ALFRED The Surgical Treatment of Experimental Coarctation (Atresia) of the Aorta, 445
- Blood Banks for Civilian Use, The Value of Nonprofit, 603
- Bone Cyst of Phalanx (Squamous Epithelial) Epidermoid, 148
- BOOK REVIEWS Gastro Enterology, Reviewed by Walter Estell Lee, 159, Surgical Errors and Safeguards, Reviewed by Charles Gordon Heyd, 960
- BOOKS RECEIVED 159 160
- Brachial Plexus Block Anesthesia An Improved Technique, 935
- BREED, E S, *et al* The Nutritional Care of Cases of Extensive Burns With Special Reference to the Oral Use of Amino acids (Amigen) in Three Cases, 815
- BROOKS, BARNEY Psychosomatic Surgery, 289
- BROWN, JAMES BARRETT Treatment of Metastatic Carcinoma of the Neck, 543
- BURNS, EDGAR Diverticula of the Urinary Bladder, 656
- BURNS, A Physiologic Analysis of the Nature and of the Treatment of, 801, A Report on the Management of, 161, Complicated by Fractures of the Extremities, the Treatment of, 526, Modified Technique in Skin Grafting of Extensive Deep 690, Nutritional Care of Cases of Extensive With Special Reference to the Oral Use of Amino acids (Amigen) in Three Cases, 815, With Sulfonamide Impregnated Membranes Further Experience with the Treatment of, 694
- BUNDAUM, LILLIAN, *et al* Crude Penicillin Its Preparation and Clinical Use Externally, 791

C

- CALDWELL, GUY A Spondylolisthesis, 485
 CAMPBELL, KENNETH N, *et al* Postoperative Salt Intolerance, 533
 CAMPICHE, PAUL A Rare Abnormality of the Bile Ducts The Antoduodenal Position of the Cystic Duct, 774
 Cancer of the Gastrointestinal Tract, Metabolic Studies in Patients with, 865
 CANNADAY, JOHN E A Report on the Healing of Wounds as Influenced by the Use of the Sulfonamides and Cotton Thread Sutures, 498
 Carcinoma, Experiment in the Early Diagnosis of Gastric, 225, Involving the Head of the Pancreas, Pancreaticojejunostomy and other Problems Associated with the Surgical Management of, 845, of the Duodenum, 342, of the Neck, Treatment of Metastatic, 543, Thyroid, with Metastases, Studied with Radioactive Iodine, 668, with Metastases, Thyroid, Studied with Radioactive Iodine, 668
 CARNEY, HENRY M, Maj, M C Presacral Dermoid, 155
 Cecum, Simple Penetrating Ulcer of, 377
 Cells, Adenomatosis of Islet, With Hyperinsulinism, 824
 Cheek, Nose and Lips, Basal Cell Lesions of the, 944
 Chemotherapy of Intracranial Infections 509, Symposium on, 498
 Chest Wounds from the Pacific Combat Area, Experiences with, 1
 Cholesterosis Its Significance in the Badly Damaged Gallbladder 391
 CHILD, CHARLES G, III Pancreaticojejunostomy and other Problems Associated with the Surgical Management of Carcinoma Involving the Head of the Pancreas, 845
 CHISHOLM, TACUE C Annular Pancreas Producing Duodenal Obstruction, 759
 Chronic Cystic Mastitis, 573, Spinal Epidural Granuloma 897
 Clinical and Laboratory Experiences with Sincyl Sulfathiazole, 518
 Coarctation (Atresia) of the Aorta, The Surgical Treatment of Experimental, 445
 COHN, ISIDORE Carcinoma of the Duodenum, 342
 COLE, WARRREN H Chronic Cystic Mastitis With Particular Reference to Classification 573
 COLEMAN, CLAUDE C Surgical Lesions of the Facial Nerve With Comments on Its Anatomy, 641
 COLLIER FREDERICK A, *et al* Postoperative Salt Intolerance 533
 COLLINS JOSEPH D Neurofibroma of the Small Intestine 362
 Combined Vascular and Nerve Injuries of Warfare, 411
 COMFORT MANDRED W Total Pancreatectomy for Hyperinsulinism Due to an Islet cell Adenoma 211
 CONE ROBERT E The Surgical Management of Cryptorchidism 591
 Congenital Atresia of the Esophagus with Tracheoesophageal Fistula 556 Pyloric Stenosis, 351
 Conservative Treatment of Acute Duodenal Fistula, 770

- Control of Pain in Posttraumatic and Other Vascular Disturbances, 432
 Cotton Thread Sutures and Sulfonamides, A Report on the Healing of Wounds as Influenced by the Use of the, 498
 Co Tui, *et al* The Nutritional Care of Cases of Extensive Burns With Special Reference to the Oral Use of Amino-acids (Amigen) in Three Cases, 815
 Crude Penicillin Its Preparation and Clinical Use Externally, 791
 Cryptorchidism, The Surgical Management of, 591
 CULP, ORMOND S, Maj, M C Treatment of Horseshoe Kidneys 777
 Cyst, A Paraumbilical Abdominal Wall, 279
 Cystic Duct, The Antoduodenal Position of the, A Rare Abnormality of the Bile Ducts, 774, Mastitis, Chronic, 573
 Cysts of the Ileocecal Junction, Enterogenous, 873

D

- DANDY, WALTER E Newer Aspects of Ruptured Intervertebral Disks, 481
 DANIELIUS, GERHARD Capt, M C Venography Its Value in the Diagnosis and Management of Venous Disturbances of the Lower Extremities, 903
 DAVISON, MARSHALL, *et al* Postoperative Chronic Progressive Gangrene of the Abdominal Wall, 796
 DAVIS, WARREN B Basal Cell Lesions of the Nose, Cheek and Lips, 944
 Dermoid, Presacral, 155
 Differential Diagnosis of Causes of Pain in the Lower Back Accompanied by Sciatic Pain, 878
 DINGWALL, JAMES A Further Experience with the Treatment of Burns with Sulfonamide Impregnated Membranes 694
 Disks, Newer Aspects of Ruptured Intervertebral, 481
 Diverticula of the Urinary Bladder 656
 Ducts A Rare Abnormality of the Bile, The Antoduodenal Position of the Cystic Duct, 774
 DUNAYER, CHARLOTTE, *et al* Crude Penicillin Its Preparation and Clinical Use Externally, 791
 DUNLAP HAROLD J, Lt Col, M C Hypertrophic Pyloric Stenosis in Adults, 124
 Duodenum Carcinoma of the, 342
 Duodenal Fistula Conservative Treatment of Acute, 770 Obstruction, Annular Pancreas Producing, 759

E

- Effect of Locally Implanted Sulfonamides on Wound Healing, 949
 EGER, SHERMAN A *et al* Primary Hemangiomatic Tumors of Skeletal Muscle, 700
 EICHELBERGER, LILLIAN Afferent Vasodepressor Nerve Impulses as a Cause of Shock Tested Experimentally by Aortic Depressor Nerve Stimulation 26
 ELIASON, E L Wilms' Tumor in a Horseshoe Kidney 788
 ELKIN, DANIEL C, Lt Col M C Combined Vascular and Nerve Injuries of Warfare, 411

- Endo aneurysmorrhaphy, The Technical Simplicity of the Matas, 468
Enteritis Involving Meckel's Diverticulum, Regional, 274
Enterogenous Cysts at the Ileocecal Junction, 873
Epidermoid (Squamous Epithelial) Bone Cyst of Phalanx, 148
Epidural Granuloma, Chronic Spinal, 897
Esophagus, Congenital Atresia of the, with Tracheo esophageal Fistulae, 556
ESTES, W L, Jr Acute Perforation in Gastro duodenal Ulceration With Special Reference to End results, 321
EVANS, EVERETT IDRIS Studies on Traumatic Shock I—Blood Volume Changes in Traumatic Shock, 64
Experiences in War Surgery in China, 134, with Chest Wounds from the Pacific Combat Area, 1
Experiment in the Early Diagnosis of Gastric Carcinoma, 225

F

- Facial Nerve, Surgical Lesions of the, 641
Fistula, The Conservative Treatment of Acute Duodenal, 770
Fistulae, Tracheo esophageal with Congenital Atresia of the Esophagus, 556
FORUM, 287
Fracture of the Fingers, Compound, 266
Fractures of the Extremities, the Treatment of Burns Complicated by, 526
FRANTZ, V KNEELAND Adenomatosis of Islet Cells, With Hyperinsulinism, 824, Thyroid Carcinoma with Metastases Studied with Radio active Iodine, 668
Frequency and Future of Gallstones Believed to be Quiescent or Symptomless, 232
Further Experience with the Treatment of Burns with Sulfonamide Impregnated Membranes, 694

G

- GAGE, IDYS M, Lt Col, MC The Technical Simplicity of the Matas Endo aneurysmorrhaphy 458
Gallbladder, Its Significance in the Badly Damaged, Cholesterosis, 391, Traumatic Rupture of the, 959
Gallstones Believed to be Quiescent or Symptomless, Frequency and Future of, 232
Gangrene, Chronic Progressive, of the Abdominal Wall, 796
GASTER, ELLEN Anesthetic Deaths in 54,128 Consecutive Cases, 954
Gastro duodenal Ulceration, Acute Perforation in With Special Reference to End results, 321
Gastro intestinal Tract, Metabolic Studies in Patients with Cancer of the, 865, Gastro intestinal Tract, Lymphosarcoma of the, 108
GERRIE, JOHN W A Report on the Management of Burns, 161
GLENN, WILLIAM W L, Capt, MC A Physiologic Analysis of the Nature and of the Treatment of Burns, 801
Grafting of Extensive Deep Burns, Modified Technique in Skin, 690
Granuloma, Chronic Spinal Epidural, 897

- GROSSMAN, MAURICE O, *et al* Chronic Spinal Epidural Granuloma, 897
GROSS, ROBERT E Annular Pancreas Producing Duodenal Obstruction, 759

H

- HAFFNER, HEINZ Cholesterosis Its Significance in the Badly Damaged Gallbladder, 391
HAMILTON, JOHN B, Lt Col, MC, *et al* Neurogenic Sarcoma of the Jejunum Associated with von Recklinghausen's Disease 856
HARVEY, HAROLD D An Experiment in the Early Diagnosis of Gastric Carcinoma 225
Healing of Wounds as Influenced by the Use of the Sulfonamides and Cotton Thread Sutures, A Report on 498
Hemangiomatous Tumors of Skeletal Muscle, Primary, 700
HENTHORPE, JOHN C Extraskeletal Osteogenic Sarcoma, 595
HEHAULT, PIERRE, Maj, MC, *et al* Neurogenic Sarcoma of the Jejunum Associated with von Recklinghausen's Disease, 856
HEYD, CHARLES GORDON Review of Surgical Errors and Safeguards, 960
HOLMAN, EMILE, Comdr, MC Experiences with Chest Wounds from the Pacific Combat Area, 1
HOOVER, M J Studies on Traumatic Shock I - Blood Volume Changes in Traumatic Shock, 64
HORN, ROBERT C, Jr Regional Enteritis Involving Meckel's Diverticulum, 274
Horseshoe Kidney, Wilms' Tumor in a 758, Kidneys, Treatment of, 777
Hyperinsulinism, Adenomatosis of Islet Cells, with, 824, Due to an Islet cell Adenoma, Total Pancreatectomy for, 211
Hypertrophic Pyloric Stenosis in Adults, 142

I

- Ileocecal Junction Enterogenous Cysts at the, 873
Infections, Chemotherapy of Intracranial, 509
Injuries of Warfare Combined Vascular and Nerve, 411
Intervertebral Disks, Newer Aspects of Ruptured, 481
Intestine, Massive Resection of the Small, 372
Neurofibroma of the Small, 362
JOB, L VIVIAN, *et al* Postoperative Salt Intolerance, 533
Iodine, Radioactive, Studied with Thyroid Carcinoma with Metastases, 668
Islet Cells, Adenomatosis of, with Hyperinsulinism, 824

J

- JAMES, G WATSON, III Studies on Traumatic Shock I—Blood Volume Changes in Traumatic Shock, 64
Jejunum, Neurogenic Sarcoma of the, Associated with von Recklinghausen's Disease, 856

K

- KENNEDY, PUTNAM C, Capt, MC *et al* Neurogenic Sarcoma of the Jejunum Associated with von Recklinghausen's Disease 856

- KESER, BENJAMIN H, *et al* Chronic Spinal Epidural Granuloma, 897
KESTON, ALBERT S, *et al* Thyroid Carcinoma with Metastases Studied with Radioactive Iodine, 668
KIDD, FRANK H A Paraumbilical Abdominal Wall Cyst, 279
Kidney, Horseshoe, Wilms' Tumor in a, 788
Kidneys, Horseshoe, Treatment of, 777
KIRGIS, H D Regeneration of Pre and Post ganglionic Fibers Following Sympathectomy of the Upper Extremity, 201
KNIGHT, MAYNARD D Congenital Atresia of the Esophagus, with Tracheo esophageal Fistulae, 556
KNOBLOCK, HILDA, *et al* Crude Penicillin Its Preparation and Clinical Use Externally, 791

L

- LAESTAR, CARL H Afferent Vasodepressor Nerve Impulses as a Cause of Shock Tested Experimentally by Aortic Depressor Nerve Stimulation, 26
LAHEY, FRANK H Indications for, and Experiences with, Total Gastrectomy, 300, Total Gastrectomy, Splenectomy, Resection of the Left Lobe of the Liver, Omentumectomy and Colectomy upon One Patient in One Operation, 222
LAMPERT, ERNEST, *et al* Postoperative Chronic Progressive Gangrene of the Abdominal Wall, 796
LARMON, WILLIAM A An Anatomic Study of the Lumbosacral Region in Relation to Low Back Pain and Sciatica, 892
LEE, WALTER E Modified Technic in Skin Grafting of Extensive Deep Burns, 690
LEHMAN, EDWIN P Clinical and Laboratory Experiences with Succinyl Sulfathiazole, 518
Lesions of the Facial Nerve, Surgical 641, of the Nose, Cheek and Lips Basal Cell, 944
LESSER, ALBERT, Capt, MC Venography Its Value in the Diagnosis and Management of Venous Disturbances of the Lower Extremities, 903
Ligation of the Abdominal Aorta for Aneurysm, 457
Lipoblasts The Malignant Tumor of, Liposarcoma, 86
Liposarcoma—The Malignant Tumor of Lipoblasts, 86
Lips, Nose and Cheek, Basal Cell Lesions of the, 944
Liver Resection of the Left Lobe of the, Omentumectomy and Colectomy upon One Patient in One Operation, Total Gastrectomy, Splenectomy 222
Lumbosacral Region in Relation to Low Back Pain and Sciatica, An Anatomic Study of the, 892
Lymphosarcoma of the Gastrointestinal Tract 108

M

- Macroducts, 144
MACNUSON, PAUL B Differential Diagnosis of Causes of Pain in the Lower Back Accompanied by Sciatic Pain, 878

- MAHORNER, HOWARD Control of Pain in Post traumatic and Other Vascular Disturbances, 432
MARSHALL, SAMUEL F Indications for, and Experiences with, Total Gastrectomy, 300
Massive Resection of the Small Intestine, 372
Mastitis, Chronic Cystic, 573
Matas Endo-aneurysmorrhaphy, The Technical Simplicity of the, 468
McDOWELL, FRANK Treatment of Metastatic Carcinoma of the Neck, 543
McSWAIN, BARTON Lymphosarcoma of the Gastrointestinal Tract, 108
Meckel's Diverticulum, Regional Enteritis Involving, 274
Membranes, Further Experience with the Treatment of Burns with Sulfonamide Impregnated, 694
MEMOIRS Lane, Sir Wm Arbuthnot, 607, Crile, George, 612, Finney, John Miller Turpin, 616, Reid, Mont Rogers, 621, Ill Edward Joseph, 624, Furness, Henry Dawson, 626, Bryn, Robert Coalter, 628 Woolsev, Ross Arlington, 630, Waring, Thomas Pinckney 631, Boldt, Hermann Johannes, 633, Flynn Charles Watts, 635, Buist Archibald Johnston, 636, Hanes, Gransville S, 638, Barnes, Frank L, 639
Metabolic Studies in Patients with Cancer of the Gastrointestinal Tract XII—Estimation and Significance of Blood Loss During Gastrointestinal Surgery, 865
Metastases of Thyroid Carcinoma, Studied with Radioactive Iodine, 668
Metastatic Carcinoma of the Neck, Treatment of the, 543
Modified Technic in Skin Grafting of Extensive Deep Burns, 690
MORTON, JOHN J Ligation of the Abdominal Aorta for Aneurysm, 457
MOYER, CARL A *et al* Postoperative Salt Intolerance, 533
MULHOLLAND, J H, *et al* The Nutritional Care of Cases of Extensive Burns With Special Reference to the Oral Use of Amino acids (Amigen) in Three Cases, 815
MURPHEY, DAVID R, JR, Maj, M C Brachial Plexus Block Anesthesia An Improved Technic, 935
Muscle, Primary Hemangiomatous Tumors of Skeletal, 700

N

- Neck, Treatment of Metastatic Carcinoma of the 543
Nerve Impulses as a Cause of Shock, Afferent Vasodepressor Tested Experimentally by Aortic depressor Nerve Stimulation, 26, Injuries of Warfare, Combined Vascular and, 411, Surgical Lesions of the Facial, 641
NEUHOF, HAROLD Acute Retroperitoneal Abscess and Phlegmon, 741
Neurofibroma of the Small Intestine, 362
Neurogenic Sarcoma of the Jejunum Associated with von Recklinghausen's Disease, 856
Newer Aspects of Ruptured Intervertebral Disks, 481

- Nose, Cheek and Lips, Basal Cell Lesions of the, 944
Nutritional Care of Cases of Extensive Burns With Special Reference to the Oral Use of Amino acids (Amigen) in Three Cases, 815

O

- OHLER, E. A. Regeneration of Pre and Post ganglionic Fibers Following Sympathectomy of the Upper Extremity, 201
Omentumectomy and Colectomy upon One Patient in One Operation, Total Gastrectomy, Splenectomy, Resection of the Left Lobe of the Liver, 222
OPPENHEIM, A., *et al* Metabolic Studies in Patients with Cancer of the Gastrointestinal Tract XXII—Estimation and Significance of Blood Loss During Gastrointestinal Surgery, 865
Osteogenic Sarcoma, Extraskeletal, 595

P

- Pacific Combat Area, Experiences with Chest Wounds from the, 1
PACK, GEORGE T., *et al* Metabolic Studies in Patients with Cancer of the Gastrointestinal Tract, XXII—Estimation and Significance of Blood Loss During Gastrointestinal Surgery, 865
PALMER, WALTER W., *et al* Thyroid Carcinoma with Metastases Studied with Radioactive Iodine, 668
Pancreas, Pancreaticojunostomy and other Problems Associated with the Surgical Management of Carcinoma Involving the Head of the, 845, Producing Duodenal Obstruction, Annular, 759
Pancreatectomy for Hyperinsulinism Due to an Islet cell Adenoma, Total, 211
Pancreaticojunostomy and other Problems Associated with the Surgical Management of Carcinoma Involving the Head of the Pancreas, 845
Parumbilical Abdominal Wall Cyst, 279
PARK, EDWARDS A. The Surgical Treatment of Experimental Contraction (Atresia) of the Aorta, 445
PARSONS, WILLARD H. Extraskeletal Osteogenic Sarcoma, 595
Pectus Excavatum, 922
Penicillin and the Sulfonamides in the Chemotherapy of Intracranial Infections, the Use of, 509, Crude, Its Preparation and Clinical Use Externally, 791
PHEMISTER, DALLAS B. Afferent Vasodepressor Nerve Impulses as a Cause of Shock Tested Experimentally by Aortic depressor Nerve Stimulation, 26
Psychologic Analysis of the Nature and of the Treatment of Burns, 801
PILCHER, COBB. The Chemotherapy of Intracranial Infections, 509
PLAUT, ALFRED. Cystoma of Seminal Vesicle, 253
Pleurus, Brachial, Block Anesthesia An Improved Technique, 935
POHLMANN, H. F. Epidermoid (Squamous Epithelial) Bone Cyst of Phalanx, 148

- Postoperative Chronic Progressive Gangrene of the Abdominal Wall, 796, Salt Intolerance, 533
Posttraumatic and Other Vascular Disturbances, Control of Pain in, 432
Preoperative Measures Used in War Surgery in China With Special Reference to the Delimiting Tourniquet, 246
Preserial Dermoid, 155
PRIESTLEY, JAMES T. Total Pancreatectomy for Hyperinsulinism Due to an Islet cell Adenoma, 211
Primary Hemangiomatous Tumors of Skeletal Muscle, 700
PRIOLEAU, WM. H. Massive Resection of the Small Intestine, 372
PRITCHARD, J. E. A Report on the Management of Burns, 161
Psychosomatic Surgery, 289
Pyloric Stenosis, Congenital, 351

R

- RADCLIFFE, JAMES, JR. Total Pancreatectomy for Hyperinsulinism Due to an Islet cell Adenoma, 211
Refrigeration Anesthesia in Surgery, 178
Regeneration of Pre and Postganglionic Fibers Following Sympathectomy of the Upper Extremity, 201
Regional Enteritis Involving Meckel's Diverticulum, 274
Report on the Healing of Wounds as Influenced by the Use of the Sulfonamides and Cotton Thread Sutures, 498, on the Management of Burns, 161
Resection of the Small Intestine, Massive, 372
Retroperitoneal Abscess and Phlegmon, Acute, 741
RHODES C. P., *et al* Metabolic Studies in Patients with Cancer of the Gastrointestinal Tract XXII—Estimation and Significance of Blood Loss During Gastrointestinal Surgery, 865
RHODES, JONATHAN E. Regional Enteritis Involving Meckel's Diverticulum, 274
RICHARDS, VICTOR. Refrigeration Anesthesia in Surgery, 178
ROSENBERG, SIDNEY A. Enterogenous Cysts at the Ileocecal Junction 873
ROSSER, CURTICE. Simple Penetrating Ulcer of the Cecum, 377
ROSSITER, LEWIS J. Chronic Cystic Mastitis With Particular Reference to Classification, 573
Ruptured Intervertebral Disks, Newer Aspects of, 481
Rupture of the Gallbladder, Traumatic, 959
RUSS, WITTEN B. The Value of Nonprofit Blood Banks for Civilian Use As Planned by the Office of Civilian Defense 603

S

- SALEEBY, ELI R. Teratoma of the Testicle, 262
Salt Intolerance, Postoperative, 533
SALTONSTALL, HENRY. Modified Technique in Skin Grafting of Extensive Deep Burns, 690

SANDERS, R L Surgical Indications in Diseases of the Common Bile Duct, 384
Sarcoma, Extraskkeletal Osteogenic, 595, of the Jejunum Associated with von Recklinghausen's Disease, Neurogenic, 856
SARNAT, BERNARD G, *et al* Postoperative Chronic Progressive Gangrene of the Abdominal Wall, 796
SCHACHTER, R J Afferent Vasodepressor Nerve Impulses as a Cause of Shock Tested Experimentally by Aortic depressor Nerve Stimulation, 26
Scitica, An Anatomic Study of the Lumbosacral Region in Relation to Low Back Pain and, 892
Sciatic Pain, Differential Diagnosis of Pain in the Lower Back Accompanied by, 878
SCOTT, W J MERLE Ligation of the Abdominal Aorta for Aneurysm, 457
Seminole Vesicle, Cystoma of, 253
SENGSTACKEN, ROYAL F Traumatic Rupture of the Gallbladder, 959
SHALLOW, THOMAS A, *et al* Primary Hemangiomas Tumors of Skeletal Muscle, 700
Shock, Afferent Vasodepressor Nerve Impulses as a Cause of Tested Experimentally by Aortic depressor Nerve Stimulation, 26
Shock, Studies on Traumatic, 64
Simple Penetrating Ulcer of the Cecum, 377
SINGLETON, ALBERT O Congenital Atresia of the Esophagus, with Tracheo esophageal Fistulae, 556
Skin Grafting of Extensive Deep Burns, Modified Technic in, 690
SMITH, CALEB H Compound Fracture of the Fingers, 266
Splenectomy Resection of the Left Lobe of the Liver, Omentumectomy and Colectomy upon One Patient in One Operation, Total Gastrectomy, 222
Spondylolisthesis, 485
STANDARD, SAMUEL Cystoma of Seminal Vesicle 253
Stenosis, Congenital Pyloric, 351
Stenosis in Adults Hypertrophic Pyloric, 142
ST JOHN FORDYCE B An Experiment in the Early Diagnosis of Gastric Carcinoma 225
STOUT, ARTHUR PURDY Liposarcoma—The Malignant Tumor of Lipoblasts, 86
Studies on Traumatic Shock I—Blood Volume Changes in Traumatic Shock 64
Succinyl Sulfathiazole Clinical and Laboratory Experiences with 518
Sulfonamide Impregnated Membranes, Further Experience with the Treatment of Burns with, 694
Sulfonamides and Cotton Thread Sutures, A Report on the Healing of Wounds as Influenced by the Use of the 498, and Penicillin in the Chemotherapy of Intracranial Infections, the Use of, 509, on Wound Healing, Effect of Locally Implanted, 949
Surgical Indications in Diseases of the Common Bile Duct, 384, Lesions of the Facial Nerve With Comments on Its Anatomy 641 Management of Cryptorchidism 591 Treatment of Experimental Coarctation (Atresia) of the Aorta, 445

Sutures, A Report of the Healing of Wounds as Influenced by the Use of the Sulfonamides and Cotton Thread, 498
SWEET, RICHARD H Pectus Excavatum, 922
SWENSON, PAUL C An Experiment in the Early Diagnosis of Gastric Carcinoma, 225
Sympathectomy of the Upper Extremity, Regeneration of Pre and Postganglionic Fibers Following, 201

T

Technical Simplicity of the Matris Endoaneurysmorrhaphy, 468
Testicle, Teratome of the, 262
THORSTAD, M JORGAN The Conservative Treatment of Acute Duodenal Fistula, 770
Thyroid Carcinoma with Metastases Studied with Radioactive Iodine, 668
TIMONEY, FRANCIS X Macroductyly, 144
Total Gastrectomy, Splenectomy, Resection of the Left Lobe of the Liver, Omentumectomy and Colectomy upon One Patient in One Operation, 222, Pancreatectomy for Hyperinsulinism Due to an Islet cell Adenoma, 211
Tracheo esophageal Fistulae, with Congenital Atresia of the Esophagus, 556
Traumatic Rupture of the Gallbladder, 959, Shock, Studies on, 64
Treatment of Burns Complicated by Fractures of the Extremities, 526, of Horseshoe Kidneys, 777, of Metastatic Carcinoma of the Neck, 543
TRENT, JOSIAH C Anesthetic Deaths in 54,128 Consecutive Cases, 954
TRUESDELL, EDWARD D The Frequency and Future of Gallstones Believed to be Quiescent or Symptomless, 232
Tumor of Lipoblasts, Malignant Liposarcoma, 86
Wilms in a Horseshoe Kidney 788
Tumors of Skeletal Muscle, Primary Hemangiomas, 700

U

Ulcer of the Cecum, Simple Penetrating, 377
Urmay Bladder, Diverticula of the, 656

V

VANCE, CHARLES A Congenital Pyloric Stenosis, 351
Vascular and Nerve Injuries of Warfare, Combined, 411
Vascular Disturbances, Control of Pain in Posttraumatic 432
Vasodepressor Nerve Impulses as a Cause of Shock Afferent Tested Experimentally by Aortic depressor Nerve Stimulation, 26
Vesicle Cystoma of the Seminal 253
VAUGHAN HERBERT H, *et al* Postoperative Salt Intolerance, 533
Venography Its Value in the Diagnosis and Management of Venous Disturbances of the Lower Extremities, 903
VOHRIS, HAROLD C, *et al* Chronic Spinal Epidural Granuloma, 897
von Recklinghausen's Disease Neurogenic Sarcoma of the Jejunum Associated with, 856

W

- WACHSTEIN, M Epidermoid (Squamous Epithelial) Bone Cyst of Phalanx, 148
WAGNER, FREDERICK B, JR, *et al* Primary Hemangiomas of Skeletal Muscle, 700
Wall Cyst, A Paraumbilical Abdominal, 279
Warfare, Combined Vascular and Nerve Injuries of, 411
War Surgery in China, Experiences in, 134
War Surgery in China With Special Reference to the Delimiting Tourniquet, Preoperative Measures Used in, 246
WARTHEN, HARRY J, JR, M, M C The Treatment of Burns Complicated by Fractures of the Extremities, 526
Wilms' Tumor in a Horseshoe Kidney, 788

- WOMACK, NATHAN A Cholesterosis Its Significance in the Badly Damaged Gallbladder, 391
WOODHALL, BARNES, MAJ, M C Combined Vascular and Nerve Injuries of Warfare, 411
Wound Healing, Effect of Locally Implanted Sulfonamides on, 949
Wounds from the Pacific Combat Area, Experiences with Chest, 1
WRIGHT, ARTHUR MULLIN, *et al* The Nutritional Care of Cases of Extensive Burns With Special Reference to the Oral Use of Amino acids (Amigen) in Three Cases, 815

Z

- ZINTEL, HAROLD A Effect of Locally Implanted Sulfonamides on Wound Healing, 949